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070CT97 E308151-1 D00254
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Request for grant of a patent

The Patent Office
Cardiff Road
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Gwent NP9 1RH

1. Your Reference 47/62849GB 07 OCT 1997

THE PATENT OFFICE
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-7 OCT 1997

2. Patent Application Number 9721170.0

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Communication & Control Electronics Limited
Stirling House
Stirling Road
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Guildford, Surrey GU2 5RF

Patents ADP number (*if known*) 07299386001

If the applicant is a corporate body, give the country/state of its incorporation

Country: United Kingdom
State:

4. Title of the invention
DEVELOPMENT TOOLS FOR COMMUNICATION SYSTEM

5. Name of Agent **FITZPATRICKS**

"Address for Service" in the United Kingdom to which all correspondence should be sent

4 West Regent Street
Glasgow
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Patents ADP number **00000695002**

6. Priority Details

Country	Priority Application Number	Date of filing
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7. If this application is divided or otherwise derived from an earlier UK application give details

Number of earlier application	Date of filing
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Patents form 1/77

8. Is a statement of inventorship and or right to grant of a patent required in support of this request?:

YES

9. Enter the number of sheets for any of the following items you are filing with the form.

Continuation Sheet for this form	-
Description	61
Claims	4
Abstract	-
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Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a Patent (*Patents Form 7/77*)	-
Request for Preliminary examination and search (*Patents form 9/77*)	-
Request for Substantive Examination (*Patents Form 10/77*)	-

11. I/We request the grant of a patent on the basis of this application

Signature FITZPATRICKS Date: 07 October 1997

12. Name and daytime telephone number of person to contact in the United Kingdom

John James GRAY

0141 306 9000

LOCAL COMMUNICATION SYSTEM

A local communication system which combines source data (CD audio, MPEG video, telephone audio etc) with control commands in a low cost fibre network is available in the form of D2B Optical. For details, see for example the "Conan Technology Brochure" and the "Conan IC Data Sheet" available from Communication & Control Electronics Limited, Stirling House, Stirling Road, The Surrey Research Park, Guildford, Surrey GU2 5RF. See also German patent applications of Becker GmbH with filing numbers 19503206.3 (95P03), 19503207.1 (95P04), 19503209.8 (95P05), 19503210.1 (95P06), 19503212.8 (95P07), 19503213.6 (95P08), 19503214.4 (95P09) and 19503215.2 (95P10). "Conan" is a registered trade mark of Communication & Control Electronics Limited.

The present invention aims to enable expansion of the capacity of such a network, for use in vehicles and the like, towards a capacity necessary for higher bit-rate multimedia applications such as MPEG2 audio, MPEG2 video, Digital Audio Broadcasting (DAB), Digital Versatile Disk (DVD) and other data.

One proposed embodiment employs asynchronous transfer mode data transport for the various data types, accommodating both high bit rate and low bit rate data channels. However, the ATM packet is not limited to the conventional ATM packet of 5 bytes of header and 48 bytes of payload, but is adapted to provide more efficient use of bandwidth in the target applications.

Also, compared with D2B Optical (CONAN) technology, it is proposed to use a more compact encoding technique for the fibre interface, such as the 4B5B or 8B10B

encoding, currently used in FDDI (Fibre Distributed Data Interface) for metropolitan area networks (MANs).

Embodiments are proposed, in which each network frame includes subframes of at least two different modes: "mode 0" subframes provide compatibility with the fixed bit-rate (e.g. circuit-switched) CONAN technology, while simultaneously the "mode 1" subframe provides a group of bytes which can be allocated more freely to implement a variable bit-rate (e.g. packet-switched) channel. In other embodiments, a common source data channel is allocated dynamically between circuit-switched and packet-switched data.

These proposals and surrounding considerations are described in the following pages, together with some alternatives also proposed herein.

1. Introduction

This document comprises an outline proposal for a high speed D2B which works with an optical interface (Plastic Optical Fibre). The proposed device is known as the high speed D2B and is designated as C&C Electronics part number HSCI8001.

2. Objectives

The objectives of the HSCI8001 development are as follows

- To integrate many of the digital audio and video systems over a common data bus and come up with a suitable protocol that will be able to integrate them.
- Baseline for the High Speed Conan
  - Use of Plastic Optical Fibre
  - Low cost LED Transceiver technology
  - Bandwidth requirements > 25 Mbs
  - Ring Topology for ease of installation, low cost Fibre Optics components and low power consumption...

3.0 Requirement Constraints

3.1 Topology

- Point-to-point links
- Linear T bus
- Star system
- Reflective star
- Transmissive Star

3.2 Line encoding

There is a need for a more efficient encoding/decoding technique than what is currently used on the current Conan chip (BI-PHASE). One type

of encoding/ decoding technique that is currently used in FDDI which would be considered is the use of 4B5B encoding technique. This would provide the High speed network a reliable and efficient technique.

- BI Phase encoding for current Conan design
- 4B5B/8B10B

3.1 Data rate Requirements

- Parameters identified for the various digital audio video systems for integration over a common databus. The tabulated values indicate the some of the overriding parameters between systems..

Data Type	Variable Bandwidth Requirements	Common Frequency	Frame Structure
MPEG2 Audio	up to 912kbps	48kbps	
MPEG2 Video	1.55 to 4Mbps		
DAB	1.5Mbps?	48kHz	16-32 Bits
DVD	11.08Mbps		2048bytes Packet
CD	1.44Mbps	44.1kHz	16-24Bits
ATM (Use this as a Transport for above Data Types)			Similar to 5bytes of Header and 48 Bytes of Payload

3.4 Topology

The communications network forms a backbone of most architectural designs and hence the interconnections can influence the final design. Network topology fall mainly into three categories.

For the application that we are considering a Ring topology is still the preferred option as it means that the components available for the Optical network will still be relatively cheap and low power, rather then going to a relatively expensive star network.

These point are discussed further in the sections below. But it is highly likely that if in a large network environment if the system could not handle the delay

then a star network could be the way forward if the components become available for the Plastic Fibre optics and are relatively cheap.

Point-to-point links:

Point to point dedicated links are used in two ways. Firstly by a dedicated link between each communicating function. Secondly by a dedicate link between terminals and using electronics in each terminal to strip off data which is addressed to that particular terminal and pass any further data to other terminal.

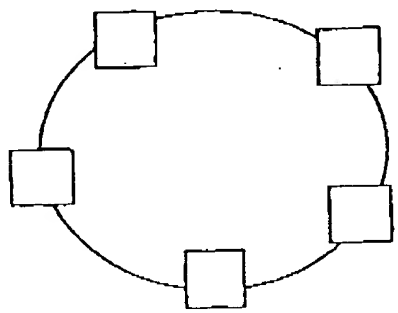

Fig. 1

Linear T- Bus

These are relatively simple to implement if using voltage mode or current mode coupling and provide a broadcast medium that allows all terminals to simultaneously listen to the traffic on the network. This has been used in many of the electrical broadcast bus designs, but is far less popular for optical systems as the excess loss at each junction leads to extremely large link power budgets.

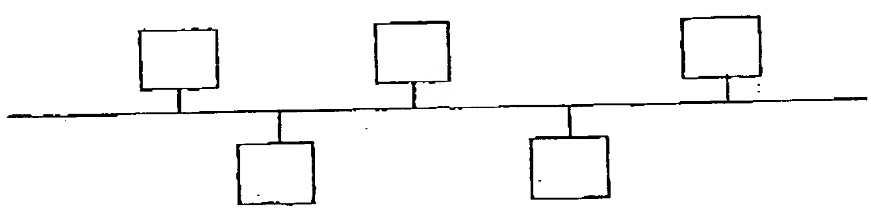

Fig.2

Stars

These can split light from a fibre into a number of other fibres in a reversible manner, that is 1:n or n:1. Many networks using fibre optics are implemented using a topology based on reflective and transmissive star couplers. But teh cost penalty is higher.

6

Reflective Star

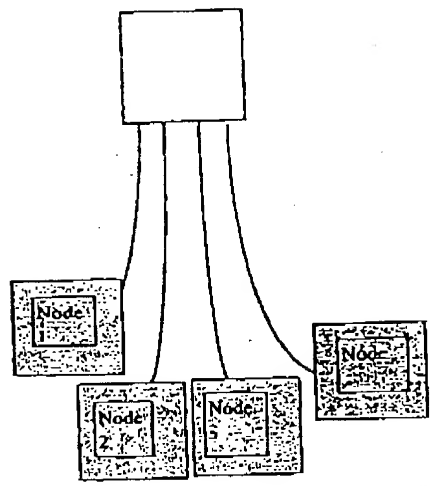

Fig. 3

Transmissive Star

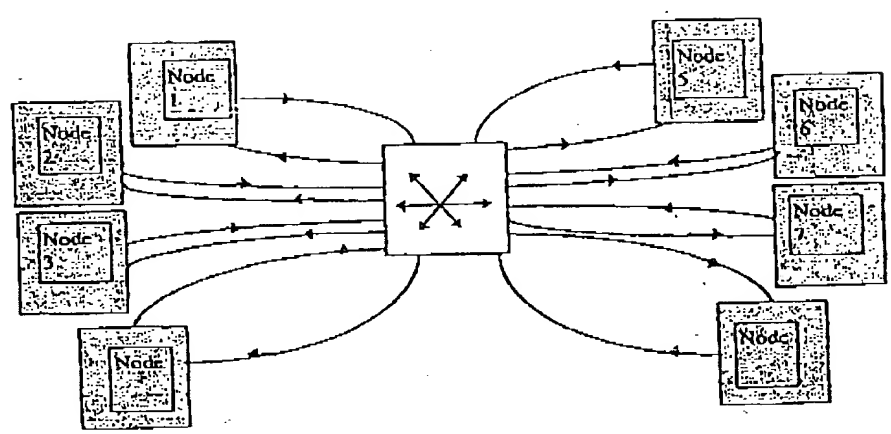

Fig. 4

Detailed Proposal I

The following pages present a first embodiment of a High Speed D2B network offering high speed variable bit rate channels ("Mode 1" data) simultaneously with fixed rate channels ("Mode 0") compatible with the known "CONAN" technology (and with the proposed "SuperCONAN" technology having an increased capacity of fixed data rate channels).

A "MegaCONAN" chip is described, a key feature of which is the provision of dual processors. The first processor is a RISC processor corresponding to that used in the existing CONAN chip for implementing the D2B system with control of the fixed data rate ("Mode 0") data routing. The second processor, handing the asynchronous ("Mode 1") data is a digital signal processor (DSP) which can implement, for example sample rate conversion, audio DSP functions (such as Dolby AC3), and can interface to on-chip or off-chip for DVD and other data formats.

8

User Technical Requirements for High Speed D2B

High Speed D2B Technical Requirements

- Synchronous, connection oriented data transfer (mode 0).
- Asynchronous, connection-less data transfer (mode 1).
- Total bus capacity can be shared between modes 0 and 1.
- Bus running at an instant mixed frame rate in the range 16 - 50 kHz. Specific frame rates which are currently foreseen are CD at 44.1 kHz, DAB/DVD Audio at 48 kHz and telephony audio at 16 kHz.
- The total minimum source data rate is 4 times higher than for current D2B Optical
- For data transfer mode 1, the prioritisation of message and/or devices should depend on the application.
- Backwards compatibility with current D2B Optical.

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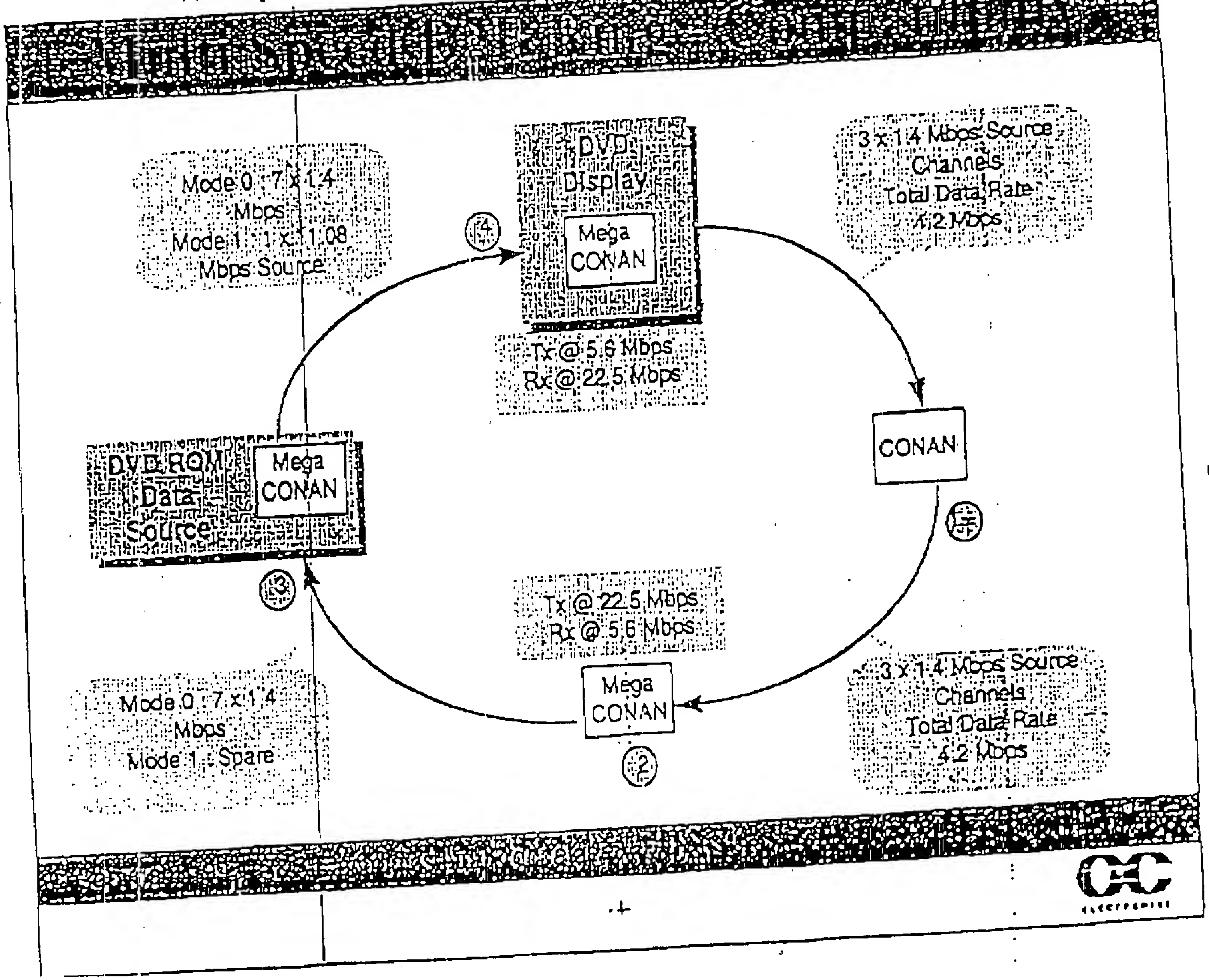
9

Multi-Speed D2B Ring - Compatibility

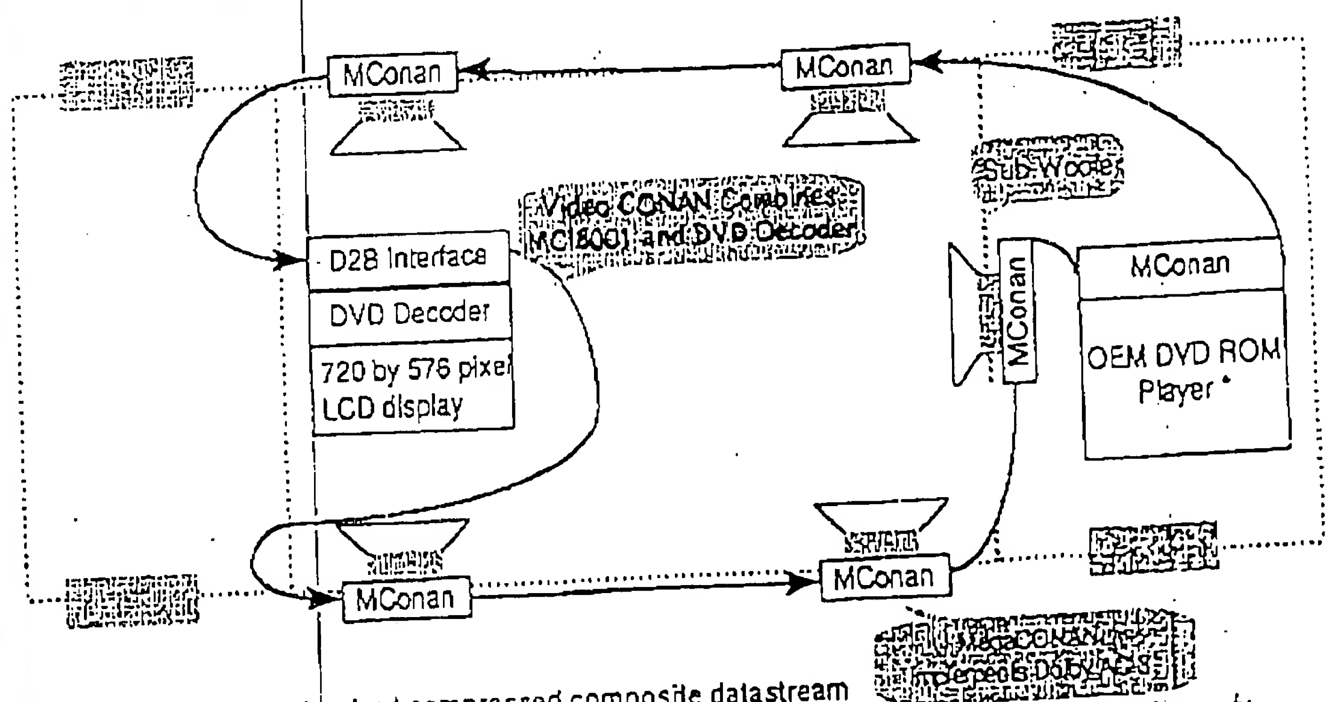


10

DVD Requirements for High Speed D2B Optical

- DVD Summary
  - Maximum 17 GByte storage (c.f. 680MByte for CD)
  - Interactive video requires control info exchange
  - Typical image resolution corresponding to MPEG2 Main Level Main Profile : 720 (H) by 480 (V) pixels at 30 fps : 9.8 Mbps max
  - Dolby AC3 5.1 audio : 48 kHz sample rate : 448 kbps max
  - MPEG2 7.1 audio : 48 kHz sample rate : 912 kbps max
  - Average data rate of 4.69 MBPS (depending on content)
  - Peak information rate of 10.08 MBPS
  - Peak System layer rate of 11.08 MBPS
- DVD ROM Part 3 Specifies mapping of audio datastreams to IEC958

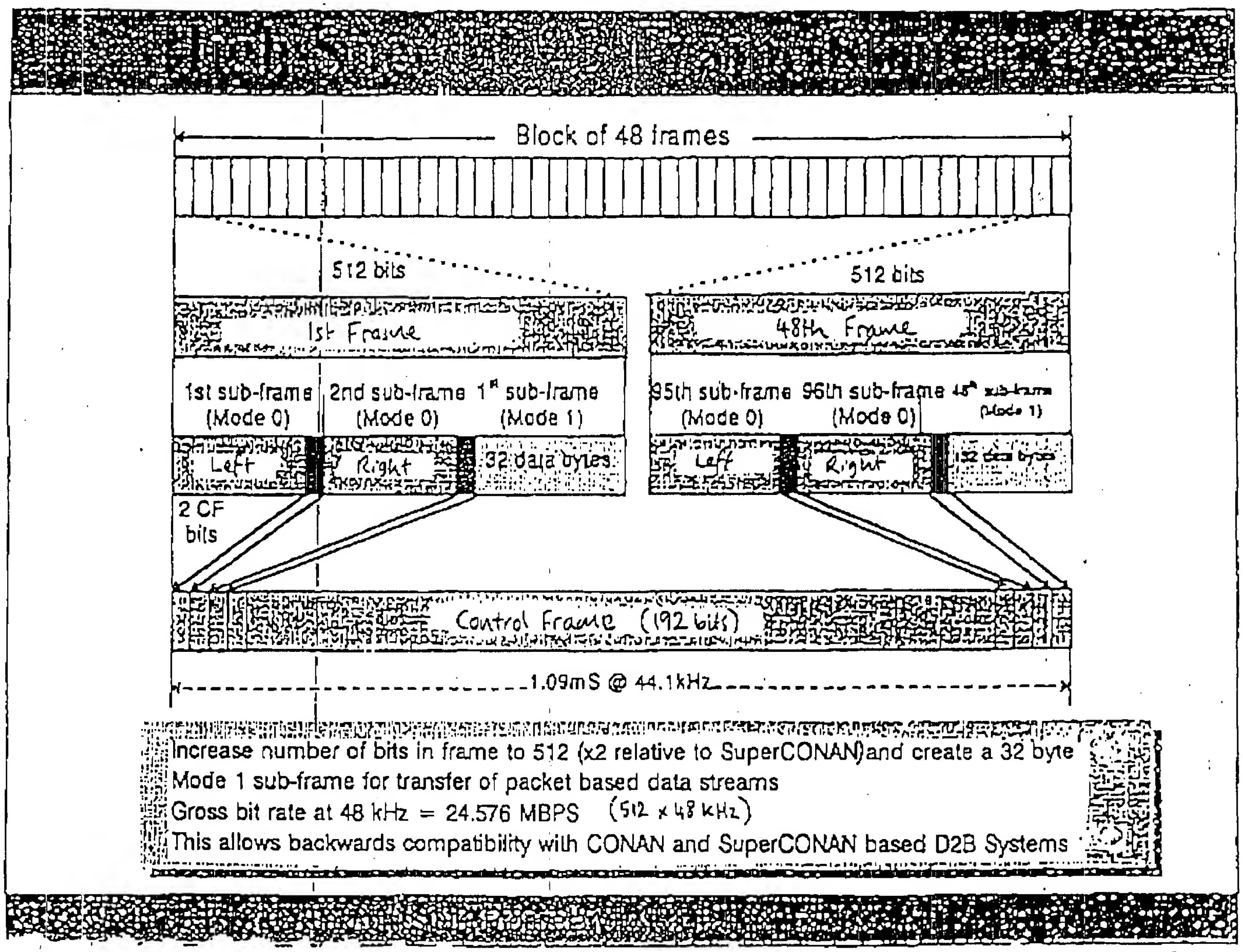
Possible Automotive DVD/D2B Topology



*DVD ROM Player must output compressed composite datastream (PES) to High Speed D2B Network (Max 11 MBPS)

12

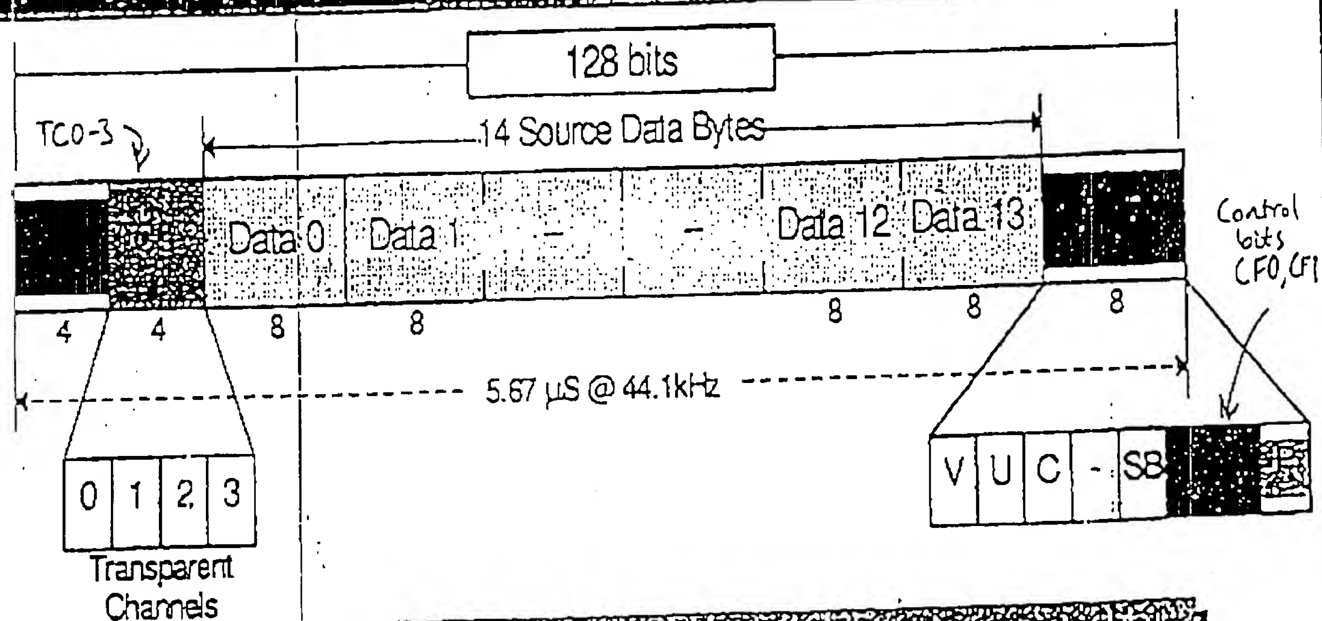
High Speed D2B Frame Structure



In other systems sub-frame order and sizes can be different within each frame, and size of control frames can vary.

13

High Speed D2B Sub-frame Structure (Mode0)

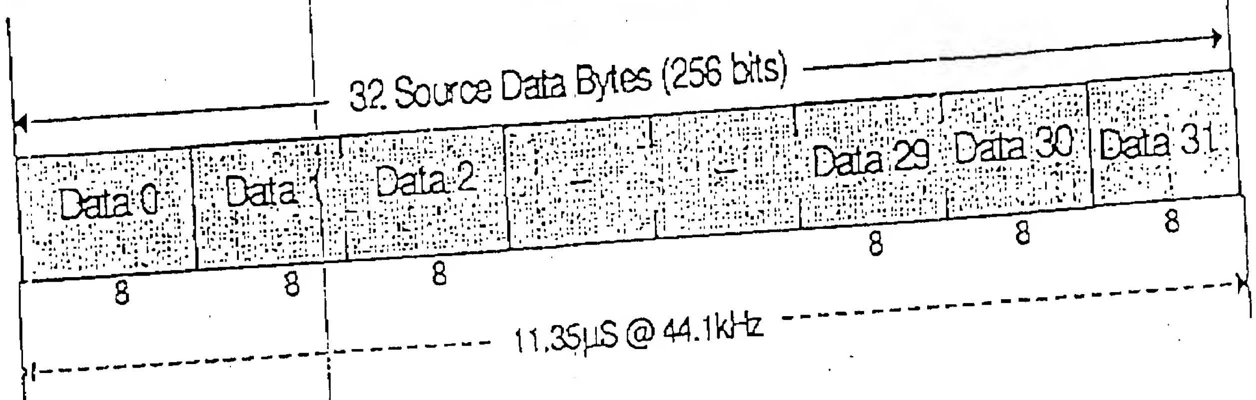


Source data rate = 2*8*14*48 kHz = 10.752 MBPS
Multiple (up to 7) CD audio channels compatible with Super CONAN frame structure
two such sub-frames (Left and Right) per frame
Circuits switched connection i.e. capacity remains fixed throughout duration of connection

Mode0 Sub-frame same as "SuperCONAN", greater capacity than CONAN itself.

14

High Speed D2B Sub-frame Structure (Mode 1)



Packet based transport allowing mix of variable bit rates in quantities of 1 byte per subframe (equal to a source data rate of 384 kBPS at Fs = 48 kHz) up to a maximum of 32 bytes per sub-frame (equal to a source data rate of 12.288 MBPS)

Dynamic Allocation of source channel capacity in Mode 1 could be communicated using the control channel For example during thetransfer of a DVD image the required data rate may vary - thus a variable bit rate control protocol could be used to assign and de-assign more or less data bytes (1-32) on a multi-frame basis (ie a control frame comprise 48 source data frames and therefore the minimum time for modifying the Mode 1 source data rate is approx 1.09 msec

Alternativley a Fast Control Channel (FACCH) could be used comprising Data 0 (384 kbps) for capacity allocation

15

DVD Dynamic Rate Control

DVD Dynamic Rate Control

- Image resolution of 720 by 480 pixels encoded using 4:2:0 YCrCb video = 124.416 MBPS. Max compressed video rate is 9.8 MBPS.
- Minimum MPEG2 compression ratio for DVD is 12.7:1.
- Maximum of 41 kbyte per frame or 218 PES payloads each of 188 bytes. (1 PES payload every 160 usec)
- Inter-frame encoding drives compression therefore, max rate of change of data rate is once per frame - approx 30 msec
- Options for dynamic allocation of High Speed D2B Mode 1 capacity are :
  - Use control channel -30 control frames every video frame ? Problem with retry timeouts ? (Depends on traffic and arbitration)
  - Use Fast Associated Control Channel (FACCH) eg dedicated packet 1 (384 kbps) to allocate Mode 1 capacity

16

Further High Speed D2B Implementation Details:

- Need to analyse and define control channel requirements in order to determine if more (or less) capacity than current 176 kbps is required
  - -- Construct simulation of typical D2B networks including DVD players and calculate control channel rate for alternative network proposals.
  - -- Repeat above exercise for packet based DVD data streams to determine how variation of DVD data rates affects Mode 1 data transfer and control channel capacity
- Decide on improved line coding approach -
  - -- eg 20% overhead using a 4B/5B code as used in FDDI networks
- Mode 1 Layer 2/3 capacity allocation could be defined in next step ?

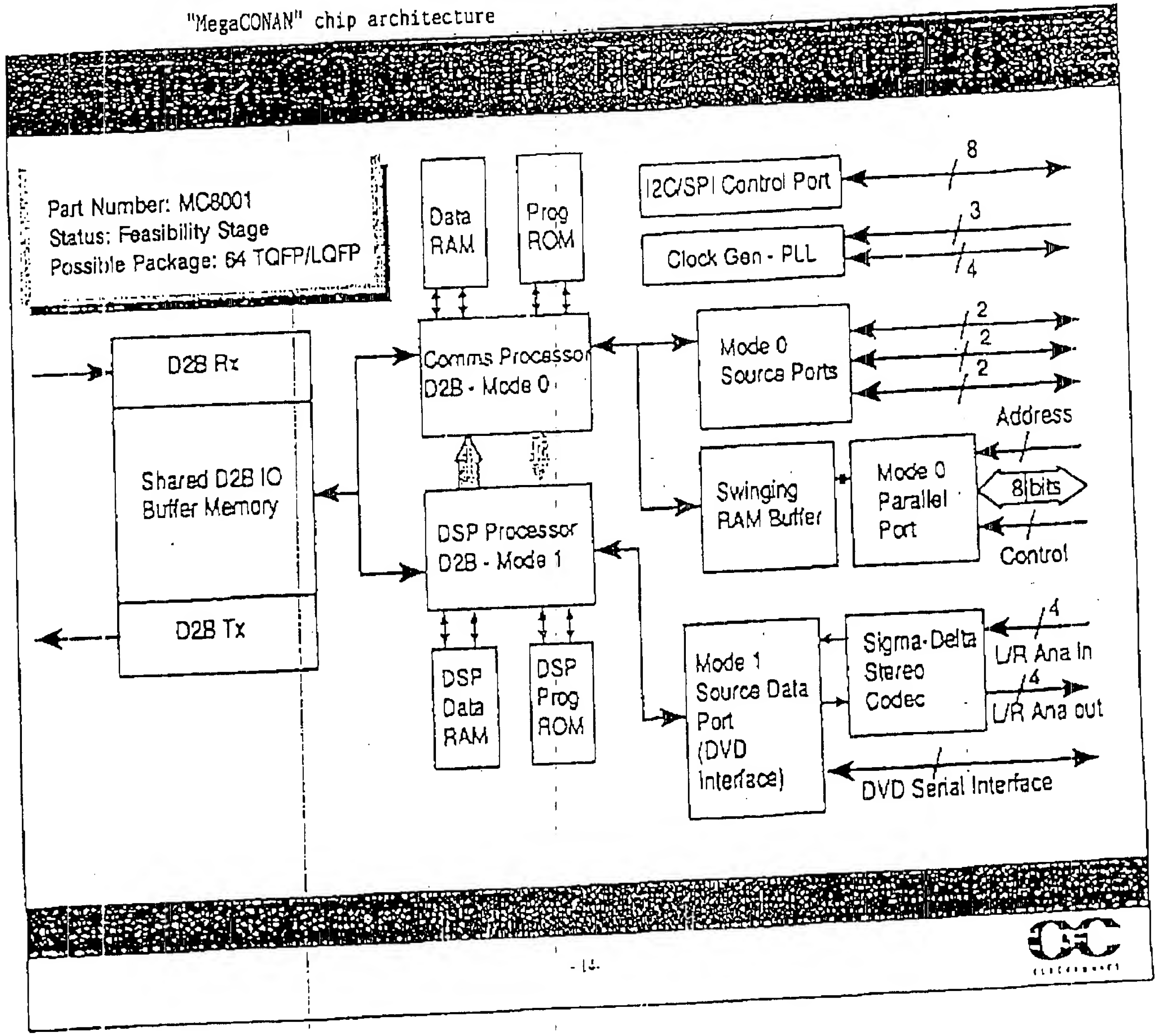
17

"MegaCONAN" interface chip for High Speed D2B

- Implements all features of High Speed D2B
- Part Number MCI8001
- D2B Gross data rate in excess of 24.576 MBPS at Fs = 48 kHz and before line coding to FOT
- Two Simultaneous Communication modes :
  - Mode 0 : Circuit switched for CONAN and Super CONAN interface
  - Mode 1 : Packet switched for variable data transfer rate from 384 kbps to 12.288 MBPS at Fs = 48 kHz
- High performance integrated stereo audio CODEC
- Fully backwards compatible with CONAN and D2B Optical networks to allow multi-speed D2B networks to be constructed

18

"MegaCONAN" chip architecture



Detailed Proposal II

The following pages present a modified embodiment, also providing both variable and fixed rate channels, but with flexible allocation of bytes within a common source data channel. Notable changes relative to Detailed Proposal I above are explained as follows:

- The delay at each network node in processing each frame of Proposal I would have been greater than 1 sub-frame when using a network containing both D2B Optical and High Speed D2B network nodes. Since a conventional D2B Optical network can only handle a maximum of 1 sub-frame delay around the network such a "mixed mode" network would not have functioned correctly. In the Proposal II the maximum delay is 12 High Speed D2B bits (= 3 D2B Optical bits) thus up to a theoretical limit of 20 nodes (16 when accounting for typical processing delays through each node) can be placed in a mixed mode network.

- In the Proposal I the allocation of circuit-switched synchronous traffic (Mode 0) and asynchronous packet based traffic (Mode 1) was fixed at 256 bits each. In Proposal II the traffic can be allocated in a flexible manner from 100% Mode 0 to 100% Mode 1 in increments of 1 source byte from 0 source bytes to 60 source bytes in a frame. Total source data capacity is now 23.04 MBPS at Fs = 48 kHz (DVD sample rate).

- The frame structure allows transmission of 1 complete ATM cell (53 bytes equivalent to a bit rate of 20.352 MBPS) in 1 frame as Mode 1 traffic

with 7 bytes left for Mode 0 traffic (2.688 MBPS or, for example, 2 stereo digital CD channels). Thus the network can be used to transparently connect nodes with ATM data interfaces, if desired.

- Compatability is maintained as before by using a common control channel structure as currently used in D2B Optical sytems (at a rate of 176.4 kbps at Fs 44.1 kHz) ("Conan" technology).

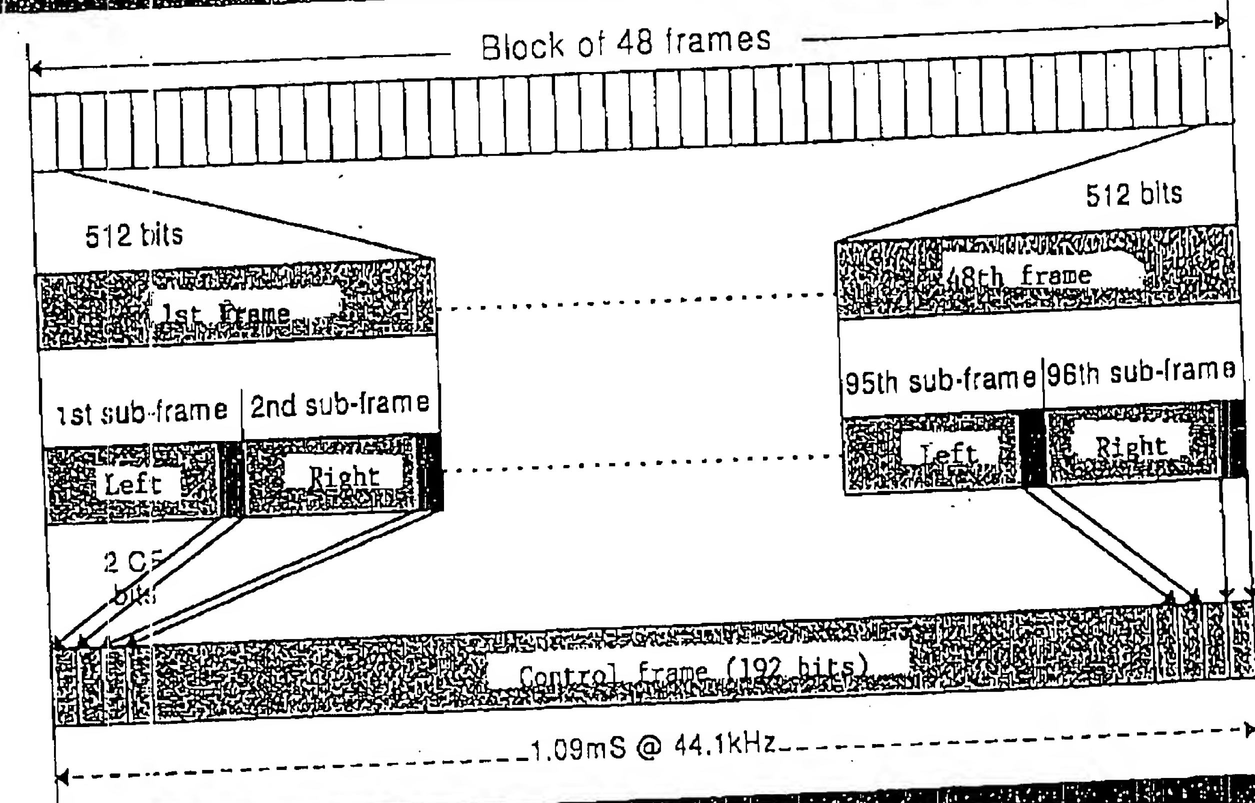
- When using a network in which all nodes are High Speed D2B Nodes additional control channel capacity can be added by using the 4 bits in the Right Pre-amble to increase the control channel capacity to 352.8 kbps at Fs = 44.1 kHz.

- Line coding efficiency is improved using 4B/5B line coding to reduce the overhead to just 20%. Thus the rate at which optical transceivers are required to be driven reduces to 29.4912 MHz (at Fs = 48 kHz) as compared to 49.152 MHz for bi-phase encoding.

Statistical multiplexing can be used to multiplex up to 4 DVD channels onto the High Speed D2B Bus. This relates to calculating node buffer sizes in a distributed video transmission network.

21

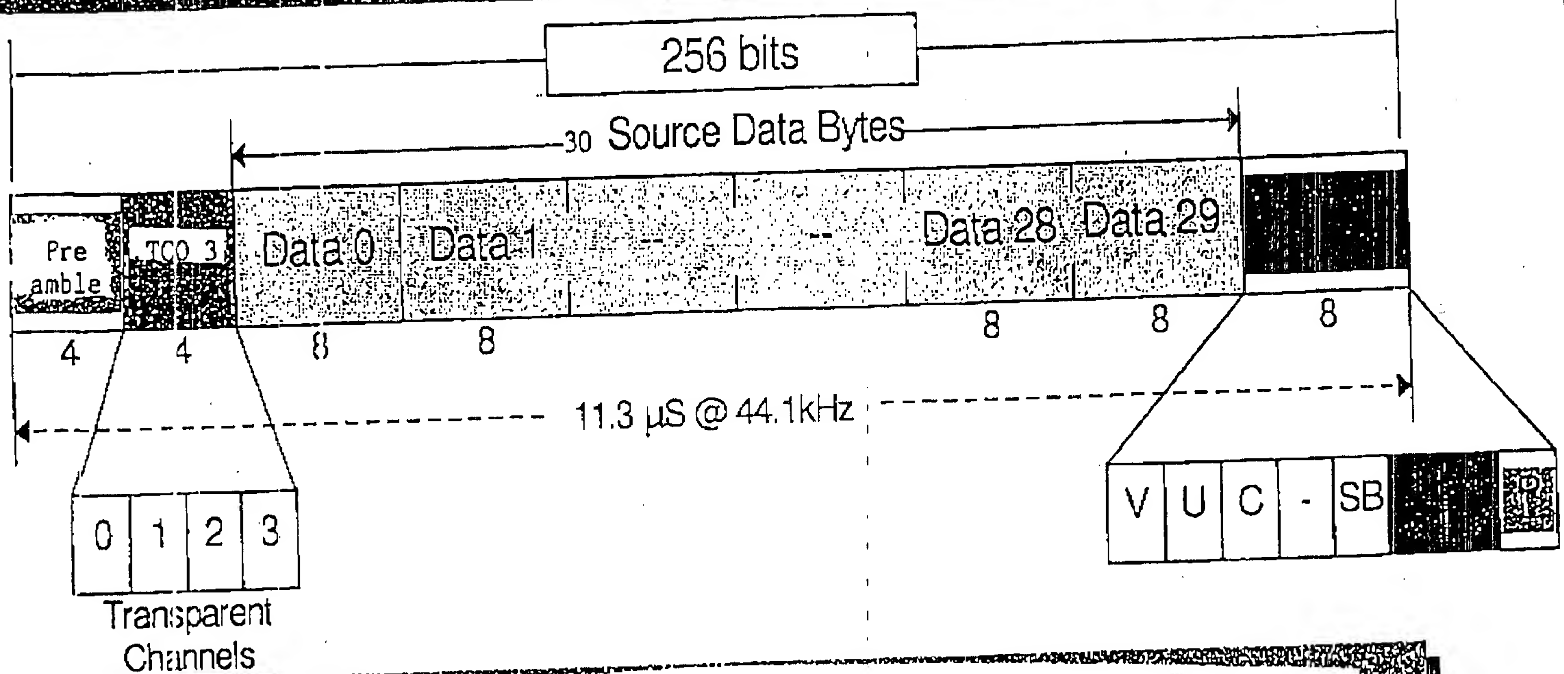
High Speed D2B Frame Structure



Mixed Mode 0 and Mode 1 data in common source channel.

Gross bit-rate 512 x 48 = 24.576 MBPS

High Speed D2B Sub-Frame Structure



Total Source data rate = 2*8*30*48 kHz = 23.04 MBPS
Synchronous (Mode 0) capacity allocated from frame start
Asynchronous (Mode 1) capacity allocated from frame end
Two such sub-frames (Left and Right) per frame
Right pre-amble (4 bits) can be allocated to control channel for High Speed D2B only networks (384 kbps at Fs = 48 kHz)

23

High Speed D2B Features

- Frame structure designed for compatibility with D2B Optical and D2B Optical Plus
  - Maximum Delay through each mode is 12 HSB bits = 3 D2B bits when in using mix of High Speed and D2B Nodes
- Asynchrononous traffic alocated in source bytes from the end of frame - Synchronous traffic from the beginning if the frame.
- Control channel format is common to D2B Optical and D2B Optical Plus
- Additional control channel capacity may be used when all nodes are High Speed D2B nodes
  - Optional use of right pre-amble to increase control capacity to 384 kBPS at Fs = 48 kHz

Detailed Proposal III

A further example will now be presented, which differs from Detailed Proposal II in various ways.

The number of source data bytes per sub-frame is increased to 46, giving a continuously allocatable 92 source data bytes per frame. The frame rate is fixed at 48 kHz, giving a higher overall data rate than in Detailed Proposal II.

Detailed Proposal III also provides more detail of the control of asynchronous channel allocation, and a package structure for data within the asynchronous channels.

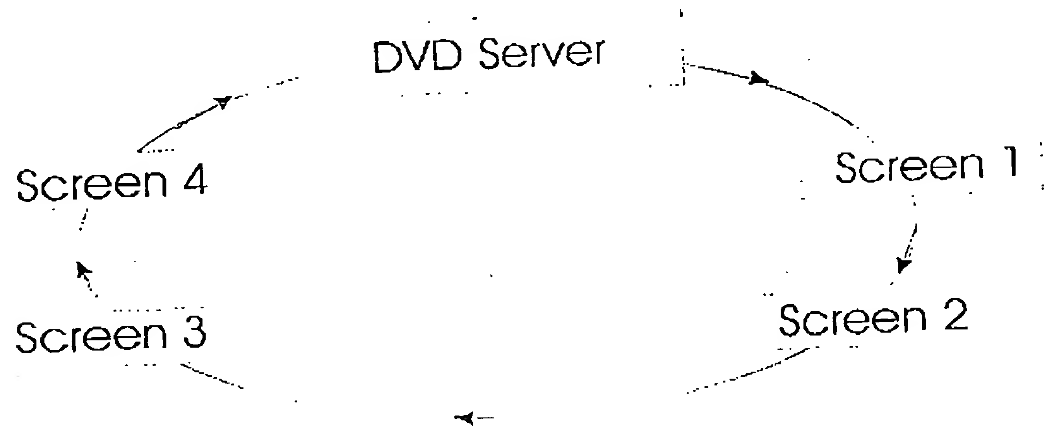
Although the variable width (asynchronous) channels and the fixed rate (synchronous) channels are again allocated within a single source data field from different ends, in this proposal the asynchronous traffic is allocated in the source bytes from the beginning of the frame, not the end. At the start of each block of 48 frames, asynchronous block headers are provided which indicate a channel ID and channel width which are fixed for the remainder of that block. The header for successive channels is found by counting through the source data bytes of the first frame in accordance with the width of each channel. The synchronous data channels are allocated from the end of the source data field.

Packets carrying 42 bytes of source data in this example can also be grouped into packs of up to 256 packets. This can assist data handling in applications where larger segments of data, such as disk segments of 2 kbytes are expected. A DVD source, for example, normally provides data in so-called PES cells of 188 bytes, which could, if desired, be grouped as pack of 5 of the proposed asynchronous data packets.

A detailed description of Proposal III now follows.

System Description

A High Speed D2B Optical system consists of a set of devices which are connected in a ring topology via a series of point to point links. Each of these links are physically independent.



Example High Speed D2B System

Depending on its function, each Device in the system can:

- supply, receive or pass-through source data (e.g. digital audio, video etc.).
- send and receive control messages

To support the sending and receiving control messages, each device has two unique addresses an application-related address and a ring-position related address. It is also possible to broadcast a control message to all devices or to a pre-selected group of devices.

The protocols for control message communication are defined in the *D2B Optical Specifications*.

HS D2B Performance

At a frame rate of 48 kHz the High Speed D2B System offers a gross data rate of 36.864 Mbps and a net source data rate of 34.56 Mbps (organised as 92 source bytes per High Speed D2B Frame).

High Speed D2B Frame Structure

The frame and sub-frame structures for High speed D2B are shown in Figures 1 and 2 respectively.

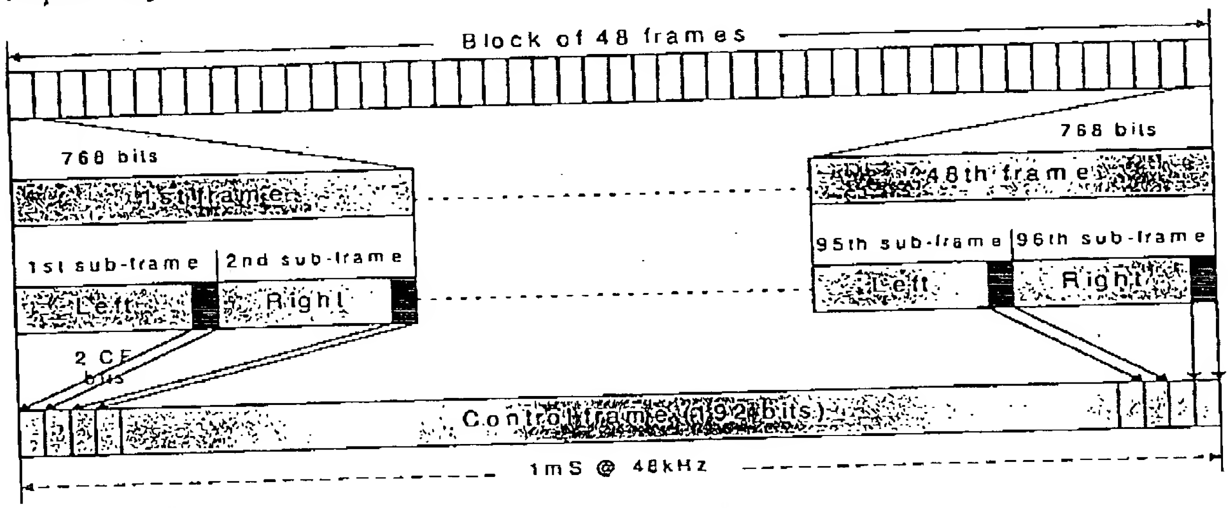
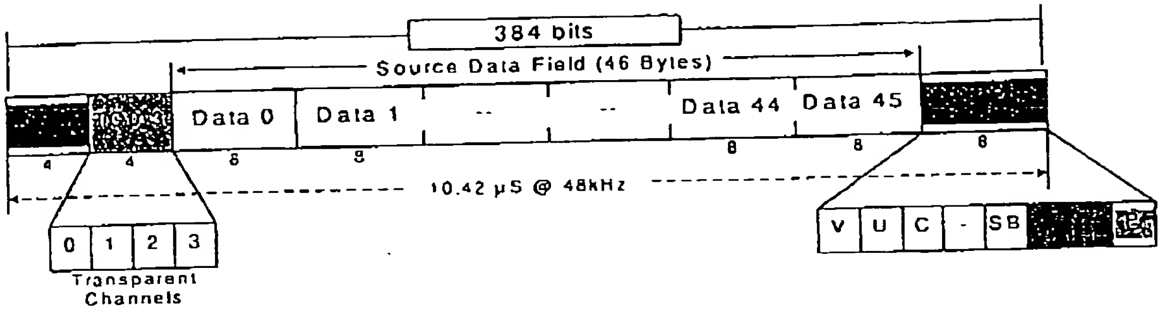


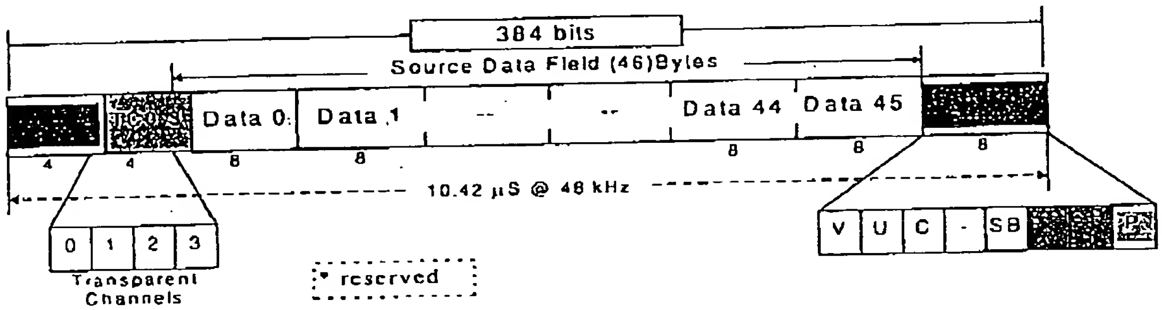
Fig 1 : High Speed D2B Frame Structure

The High Speed frame consists of two identical sub-frames, to provide some compatibility with the earlier CONAN system as in Proposal II, but this is not essential. The frame rate is proposed to be fixed at 48 kHz. Synchronous channels requiring a lower rate (e.g. CD audio, MPEG 1) can be padded and buffered accordingly within the synchronous data channels.

First Subframe



Second Subframe



In other embodiments, the number of bits in the frame and hence the number of bytes in the source data field may be different.

Error Protection

The HS frame is protected by 2 parity bits, 1 in each subframe.

Source Data Transport

Whenever source data (e.g. digital audio or video) needs to be transported over HS D2B, a source data connection must be established. This is called *connection set-up*. During the set-up, the required number of source data channels (bytes) are allocated from free channels within the HS D2B. For example, to carry a stereo audio signal from a CD player requires an allocation of 4 bytes. Source Data Connection protocols based on control messages are used for setting-up and removing connections. *

For synchronous connections, this capacity remains allocated until the connection is removed. Synchronous connections have no superimposed framing or packet structure, although applications are free to provide structure as desired.

For asynchronous connections, the connection set-up establishes the starting allocation. However this allocation can be varied during the lifetime of the connection as described in the section on Asynchronous Connection Blocks.

When all the capacity has been allocated, attempts to build further connections will fail. When this happens, the controlling AVC must decide which existing connection(s) (synchronous or asynchronous) need to be removed to release enough capacity for the new connection. The complexity of the allocation is hidden from the controlling AVC since each device is responsible for managing the allocation in its own output link (ring segment).

Allocation of Source Data Capacity

The source data field comprises the source data fields of the two sub-frames (with 46 + 46 bytes capacity), flexibly partitioned into variable size sections as shown in the diagram.

The first part is allocated to variable-rate asynchronous transport: whilst the synchronous (or fixed-rate asynchronous) source data capacity is allocated starting from the end of the frame.

* Source data routing is similar to that of the CONAN IC, but with a larger number of bytes per frame, and hence a far greater number of switching permutations. Connection building can be performed for example by protocols based on the disclosure of EP-A-0360338 (PHN 12678) and EP-A-0432316 (PHN 13189), adapted according to the ring topology protocols for this purpose are established using the control message frames to carry pre-arranged connection request instructions.

Source Data Field Structure

Left Subframe			Right Subframe		
Preamble	Source Data	Control & Status	Preamble	Source Data	Control & Status

ACB1	ACBn	FrB	SCB

1. **ACB1..ACBn** are Asynchronous data Connection Blocks — A bytes (variable)
2. **FrB** represents free capacity for asynch (or sync) conns. — 92 - (A+S) bytes
3. **SCB** represents the synchronous data connection block — S bytes (variable)

Asynchronous Connection Blocks (ACB)

Asynchronous connection blocks are the means by which multiple variable-rate source data connections can be carried on HS D2B. They are the containers for asynchronous connections within the HS frame, carrying the packet switched data. Since more than one ACB may be present in the same frame allowing multiple simultaneous asynchronous connections.

The ACB is segmented over a block of 48 HS frames (aligned to the block of 48 frames used for transporting control message frames, see figure 1). Note that the ACB header appears only in the first frame of the block of HS frames. The size of the ACB is: ACB width * 48 bytes. Thus by varying the width of the ACB from block to block, the capacity occupied by an asynchronous connection can be varied, subject to the limit of the total capacity of the frame.

Asynchronous Connection Block (ACB)

		ACB			
HS Block	HS Frame 1	ACB1	ACBn	FrB	SCB
	HS Frame 2	ACB1	ACBn	FrB	SCB
	HS Frame 48	ACB1	ACBn	FrB	SCB

Example Application

The system shown on the first page consisting of a DVD server sourcing 4 different video signals could make use of the following source data field structure. The bit rate allocation may be varied for each connection as described in the section on Asynchronous Connection

Blocks. Note that since the destinations for the video signals are distributed around the system, not all asynchronous connections need to be present in all links in the system. For example, the asynchronous connection carry the video signal to Screen 1 (video 1) needs only to be present in the link from the DVD server to Screen 1. Each of the asynchronous connections could have a starting width of 24 bytes (per frame) and then could be varied individually as required for the variable rate video signal.

Source Field Data Allocation for Multiple Video Sources

Asynchronous Connections

ACB1 video 1	ACB2 video 2	ACB3 video 3	ACB4 video 4	FrB	SCB

HS Frame Source Data Field (92 bytes)

Error Protection

The contents of the Asynchronous Data Connection Blocks rely on protection within packets.

Each Asynchronous Connection Block (ACB) is structured as follows:

Asynchronous Connection Block (ACB)

ACB Header	ACB Data

ACB-Header

ACB ID	6 bits
Start of Packet flag	1 bit
Reserved	1 bit
ACB width	7 bits
Reserved	1 bit

Notes

1. The *ACB ID* enables a receiving device to identify the connection whose data is carried by this block.

2. The Start of Packet flag indicates whether the first data byte of this ACB is also the first byte of a packet (flag set to 1) or whether it is a continuation of a packet. This allows for longer packets than the type detailed below, for example.

3. The Reserved fields is for future extensions.

4. The ACB width field indicates the number of (consecutive) bytes allocated to this asynchronous connection within each frame, encoded such that 1 means 2 bytes, 2 means 3 bytes etc. The minimum width of two bytes ensures space for the header in the first frame of the block. The ACB width may be restricted to ensure an integral number of packets within a block, where packet and/or frame sizes vary from these examples.

ACB-Data

Within the capacity provided by the ACBs, source data is carried in the form of packets. The packet format is described in the following section.

The ACB header format and its field sizes can be different according to the application.

Free Capacity (FrB)

The free capacity is held within an Asynchronous Connection Block (ACB) with ID = 0. This allows the hardware to identify the synchronous connection blocks easily.

Synchronous Connection Block

This block van be used to carry both synchronous signals e.g. 16 bit PCM audio at 48 kHz or asynchronous signals whose bit-rate is fixed. Changes to the contents and size of this block can only be made by setting up a new connection or removing an old connection. These operations are defined in the source data connection protocols [1].

Packet Structure

Asynchronous Data carried within either asynchronous or synchronous connections is formatted into packets whose structure is described below. This provides framing to allow a device receiving the data to identify the data and recover it correctly. Since each packet has its own ID, it is possible to interleave different streams of data over the same connection. For example a particular connection might carry predominantly packets containing video data interleaved with an occasional packet for control purposes.

Packet Format

Packet Header	Data	CRC

Packet Header

Packet Type	2 bits (the remainder of the packet definition applies for type 0)
Packet ID	3 bits
Reserved	1 bit
Flow Control	1 bit
Start of Pack	1 bit
Remaining Packets	8 bits
Number of bytes used.	8 bits

Packet Data

Data	42 bytes

Error Protection

Checksum/CRC	1 byte

Notes on Packet Header

1. Packet Type identifies the format of the packet, for example longer packets may be provided for bulk data transfer, as opposed to real-time channels.
2. Packet ID identifies the type of data contained in the packet, such as audio/video/general data, to assist routing in the destination device. Packet ID "7"H is reserved for control (e.g. connection management) messages, with low latency compared with the existing control message channel (CF bits).
3. Flow Control is used by a receiver of the data to indicate that its Rx buffer is full (when this flag is set to 1). When this is detected by the source of the data, it will normally suspend transmission.
4. *Remaining Packets* indicates the number of packets remaining within the current pack (group of packets)
5. *Number of Bytes* used indicates the number of bytes in this packet containing valid data

Flow Control

The flow control mechanism implemented via the flag in the packet header, requires there to be a connection from the destination device back to the source device. This connection, which would be built as part of the connection set-up of the signal whose flow is being controlled can have a much reduced capacity (minimum 1 byte per frame) compared with e.g. the video signal to which it refers. It may for example have the same ACB ID, and use the Packet Header format. A single byte channel Could also be allocated as an SCB.

Alignment of a packet within an Asynchronous Connection Block

The start of the packet is indicated by the Start of Packet bit in the ACB header. When this bit is set, the first byte of data following the ACB header is also the first byte of a packet. When this bit is not set, it indicates that the contents of the ACB are a continuation of a previous packet.

Segmentation of the Packet

The number of HS frames required for transmission of a packet is a function of the size of the packet and the width of its containing ACB in each HS Frame. If the ACB is *n* bytes wide then the packet will encompass (packet_size + size of ACB Header)/ 48n HS frames.

Diagram showing how packets are loaded into an ACB

The diagram below showing how an ACB of width 6 bytes is loaded with packets (of size 46 bytes). This ACB holds six packets of which the first two are shown (A and B). Note that the ACB header occupies the first two bytes and that between each packet are 2 reserved bytes which are used as padding. Each ACB occupies the next available group of bytes, according to the specified width of each channel. If a connection becomes wider or narrower at the next ACB, the ACB for other connections are shifted up or down accordingly.

Packets carried in an Asynchronous Connection Block (ACB)

	ACBn					
Fr. 1	ACB_H	ACB_H	pA1	pA2	pA3	pA4
Fr. 2	pA5	pA6	pA7	pA8	pA9	pA10
Fr. 8	pA41	pA42	pA43	pA44	pA45	pA46
Fr. 9	Res.	Res.	pB1	pB2	pB3	pB4
Fr. 10	pB5	pB6	pB7	pB8	pB9	pB10
Fr. 16	pB41	pB42	pB43	pB44	pB45	pB46

Key
Fr. .... Frame
ACB_H ..... ACB Header
Res. .... Reserved
PA1 .... Packet A, first byte

Packet Buffers

Each HS D2B device which needs to send or receive asynchronous data will require buffers for packets which have been received or are to be sent. The size of these buffers will be defined according to requirements.

DETAILED PROPOSAL IV

A further proposal is now presented, which is substantially the same as the third proposal but defines certain mechanisms and communication channels for flow control in the asynchronous data.

In particular a special connection signalling channel is built among the source data fields. Flow control implemented by each source adapts to minimum and maximum data rates signalled by other sources. A source data latency specific to the installation is accounted for in the flow control calculations and by means of a transition period between blocks. Mechanisms for determining the source data latency automatically are provided.

Also buffer occupancy signalling for the control channel is provided, to improve the efficiency of utilisation where one station such as the system master receives a disproportionate amount of control message traffic.

Features of High Speed D2B Optical (HS D2B)

1. Source Data Capacity of more than 43 Mbits/second, per point-to-point link
   a) Since each link is physically independent of any other link, this means that, by optimisation of relative device positions, the total system capacity can be much greater than the capacity of any single link.
2. Supports transport of Asynchronous Data as well as Synchronous Data
   a) data can be carried regardless of its timing relationship with the system
   b) simpler to implement applications requiring asynchronous data
3. Supports Variable-rate connections as well as fixed rate connections
   a) enabling more effective sharing of transport capacity between application whose demand is variable
4. Same Control Message format as that of D2B Optical
   a) backwards compatibility for D2B Application Protocols
   b) applications requiring faster control message transport can now make use of asynchronous data connections to provide as fast a link as required

HS D2B Performance
Operating at a frame rate of 48 kHz the High Speed D2B System offers a gross data rate of 43.78 Mbps and a net source data rate of 43.01 Mbps (organised as 112 source bytes per High Speed D2B Frame).

2. Glossary

HS D2B High Speed D2B Optical. This is the high bandwidth multi-purpose data communication system described in this specification.

Variable rate connections These are source data connection whose use of the source data capacity can be adjusted to meet the requirements of the application without wasting source data capacity. They enable an efficient sharing of capacity between a number of applications whose need for bandwidth varies from time to time. This type of connection is suitable for variable bit rate signals such MPEG-encoded video streams from devices such as DVD players. Variable rate connections are *asynchronous* in general.

Fixed Rate Connections These are source data connection whose use of the source data capacity is fixed when the connection is set up and is guaranteed through the lifetime of the connection. This type of connection is suitable for fixed bit rate signals such as PCM audio. There are two types of fixed connection: *synchronous* and *asynchronous*.

Asynchronous Connection (Variable or Fixed Rate) The raw synchronous rate provided by channels within the HS D2B source data field can adapted (padded) to data streams which require lower delivery rates. The application may provide data for an asynchronous connection either at a constant rate or in bursts, subject to buffer capacities within the source and destination devices. HS D2B also provides a mechanism for

regulating the delivery of data over an asynchronous connection according to the demands of the destination rather than the source. For example a destination for CD-ROM data may consume data at a variable rate and can demand data whenever it needs.

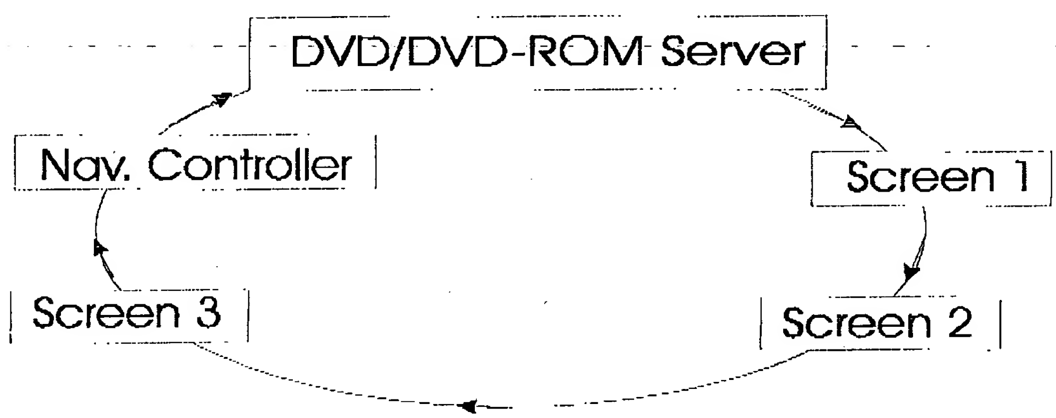
Synchronous Connections (Fixed Rate) These are connections which take full advantage of the raw synchronous rate provided by channels within the HS D2B source data field. There is no packet overhead associated with this type of connection and thus it is a very efficient use of system capacity subject to the constraint that the source must provide data at a rate which matches the system frame rate and the destination must be able to consume the data at exactly this rate. This type of connection could be use to transport PCM audio from a DAB receiver to an audio amplifier, for example.

3. System Description

A High Speed D2B Optical system consists of a set of devices which are connected in a ring topology via a series of point to point links. Each of these links is physically independent of any other link.

Example System

The diagram shows an example of a High Speed D2B system which supports video, navigation and telephone applications.



Example High Speed D2B System

Depending on its function, each device in the system can:

- supply, receive or pass-through source data (e.g. digital audio, video etc.).
- send and receive control messages

To support the sending and receiving control messages, each device has two unique addresses an application-related address and a ring-position related address. It is also possible to broadcast a control message to all devices or to a pre-selected group of devices.

The protocols for control message communication are defined in the *D2B Optical Specifications*.

3.1 System Frame Rate

The High Speed D2B System will operate at a single frame rate: 48 kHz

3.2 High Speed D2B Frame Structure

The frame structure for High speed D2B shown in the figure above contains .

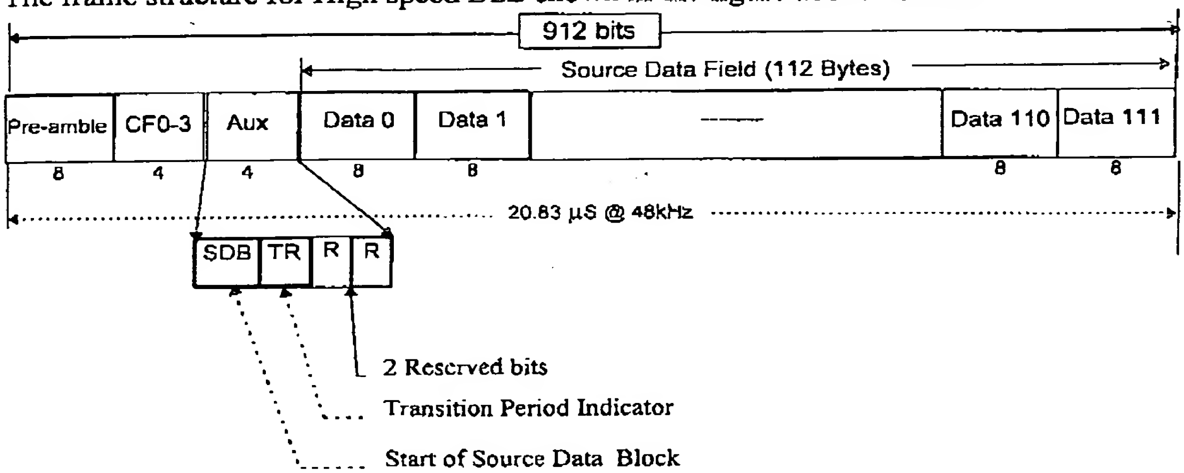


Figure 2: Frame Structure

The frame structure for High speed D2B shown in the figure above contains the following fields

Preamble

The preamble enables the receiver to recognise the start of an HS D2B frame and also to determine whether or not the frame is the starting frame of a *CF block* or not [The CF block structure, described in a later section, is used for Control Message Frame transport]. These preambles are as follows:

Preamble	Encoding
Start of Block	ESC '1011'
Start of Frame	ESC '1111'

See the section on *Line Encoding* for further details. [Compared with D2B Optical, the HS D2B frame preamble has been extended from 4 to 8 bits to suit the line encoding. However this increase is cancelled by the use of only one preamble per frame compare with one preamble per subframe in D2B Optical.

SDB Bit

The first frame of the source data block is indicated by the SDB flag being set to 1 (by the System Master). In all other frames SDB is set to 0.

Tr Bit

For the purpose of implementing variable rate connections, a Transition Period is defined for phasing in rate changes just prior to the start of a new source data block. The frames transmitted during the Transition period are marked by the Tr bit set to 1, whilst all other

frames have this bit set to 0. See the section *Phasing in VCB Width Changes* for further details.

TC0-3: Transparent Channels
These bit-wide channels are subject to the same delay in each HS D2B Node as the data in the source data field. The transparent channel can be used, for example, to provide a network continuity indicator. Compared to D2B Optical, the number of transparent channel bits per frame has reduced (from 8 to 4) since HS D2B provides other more flexible mechanisms for transporting asynchronous data over a much wider range of data rates. See the section on *Source Data Connections* for more details on this.

CF0-3: Control Message Channel
This channel is supported with 4 CF bits/frame, in exactly the same way as D2B Optical. Applications requiring faster control message transport can use fixed asynchronous source data connections as very high speed control channels, where the control messages can be sent within the same packet format as source data. For example, with one frame byte allocated to the connection, such a channel could offer a gross rate of 384kbits/sec., cf. the existing channel capacity of 192kbits/second. Such high speed channels could be dedicated either to one particular application or could be shared among applications, depending on how the fixed asynchronous connection is built.

Source Data Field
This carries all the data for source data connections. See the section on *Source Data Connections* for further details.

3.2.1.1 Error Protection

The HS frame is not protected. However note that the source data contained within the Source Data field may have its own protection where necessary. Also note that the control message frames have their own protection (see the D2B Optical Specifications for details).

3.3 Frame Rate

The High Speed D2B System operates at a frame rate of 48 kHz.

4.

Block Structures in HS D2B

There are two block structures in D2B

- one associated with the transport of control messages
- one associated with the transport of source data

4.1 CF Block

A block of 48 High Speed Data frames is used for the purpose of transmitting control message frames, carried via the 4 CF bytes in each HS D2B frame. The start of a block is indicated via a special preamble which replaces frame preamble every 48 frames.

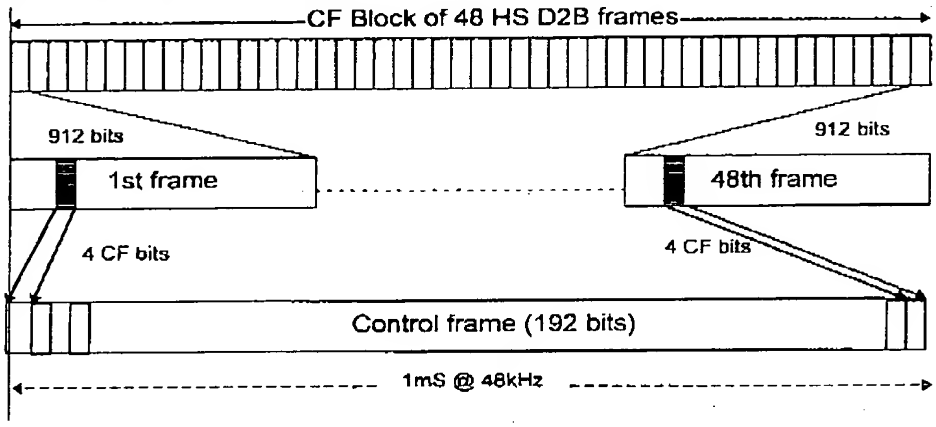


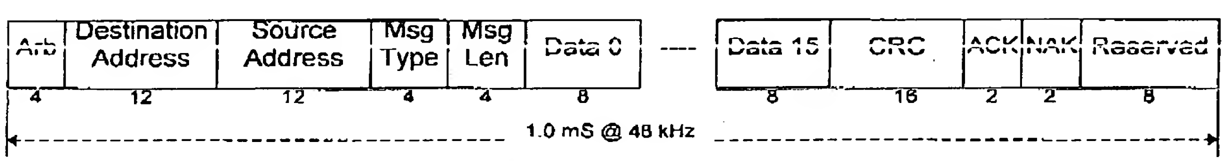
Figure 3 : CF Block Structure

4.2 Control Message Frame

The control message frame is identical to that in of D2B Optical Block, apart from an expansion of the arbitration field to 4 bits and a corresponding contraction in the reserved bits at the end of the frame.

4.2.1 Control Frame

The control frame is assembled from and aligned with a block of 96 sub-frames, i.e. the first two bits of a new control frame are taken from the sub-frame with a block preamble, and subsequent pairs of bits are taken from subsequent sub-frames to build up a control frame.



Control Frame

The fields of the control frame are:

- **Arbitration bits** *:*
  This four bit field is used to signal whether or not the current control message frame is

free. It is also used to indicate the occupancy of the system master's Rx Buffer. The first two bits (bit 0 and bit 1) of the arbitration field are reserved. The second two bits indicate the functions listed below.

Function Indicated	**Bit 2**	**Bit 3**
Control message frame is free & System master's RX buffer is free	0	0
Control message frame is free & System master's RX buffer is occupied	0	1
Reserved	1	0
Control message frame is occupied	1	1

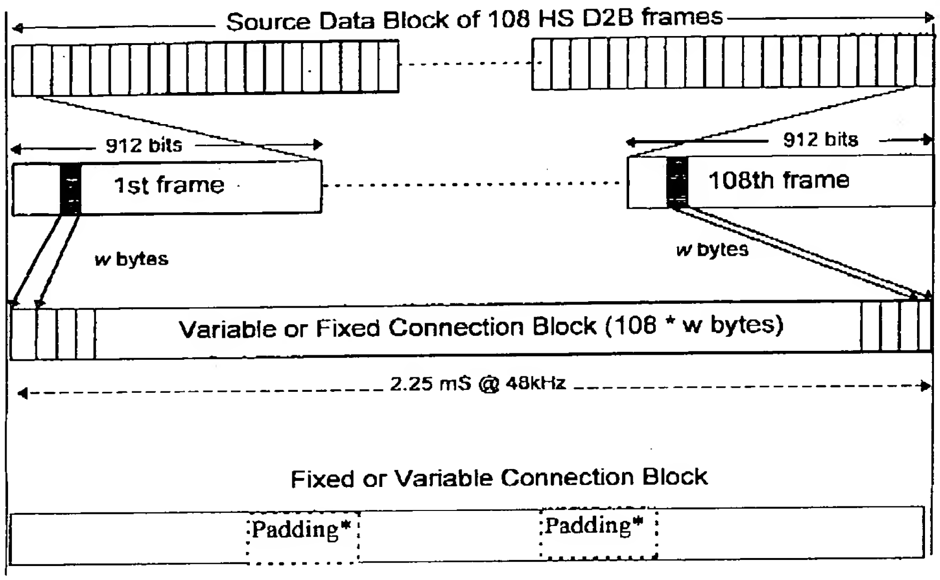
- **Destination Address**
  This is the 12-bit device address of the destination of the message, in the range '000'H to 'FFF'H. The sending device writes this into its message transmit buffer for transmission. Certain addresses and address ranges have special meanings (see section 2.6).
- **Source Address**
  This is the 12-bit device address of the sender of the message, in the range '000'H to 'FFF'H. The receiving device can read this from its message receive buffer after reception. Certain addresses and address ranges have special meanings (see section 2.6).
- **Message Type and Length**
  Two 4-bit fields normally used to indicate the type/length of the message. These bits are transported transparently by Conan.
- **Data 0 to 15**
  The message data. All 16 bytes are always transported. The Message Length normally indicates how many of the 16 bytes are actually valid for the message. The sending device writes this into its message transmit buffer for transmission. The receiving device can read this from its message receive buffer after reception.
- **CRC**
  A 16-bit Cyclic Redundancy Check value is used to verify that the control frame has been transported without error. The CRC is generated by Conan automatically on message transmission and checked by Conan automatically on message reception.
- **ACK/NAK**
  Acknowledge and Not Acknowledge (2-bits each) indicate successful message transmission. The use of separate ACK and NAK flags allow reliable point-to-point *and* broadcast message transport. The flags are automatically filled by the destination device(s) (if present) and read by the sending device.
- **Reserved** : 8 bits reserved.

Bit order within Control Frame Fields
The data is always transmitted and received LSB first in each field.

4.3

Source Data Block

A block of 108 HS D2B frames is used for the purpose of transmitting source data, supporting the packet structure for the asynchronous connections (both fixed and variable). Fixed Synchronous connections carry a constant amount of source data in each frame regardless of the position of the frame within a Source Data Block and are thus not dependent on the source data block structure. The start of a block is indicated via the *SDB* bit in the header of the D2B Optical frame (See the Frame Structure in Figure 2).
(Note that the Source Data Block is not necessarily aligned with the CF block described in the previous section)



Key: *w* .... Width of connection in bytes. [For variable-rate connections: *w* is variable, and the connection segment shown above is then called a Variable Connection block (VCB)]

N ..... Number of packet slots. Since each packet slot contains 108 bytes: *N*=*w*

* Note that the diagram shows only an example of the use of padding. Padding can occur at any point with a variable or fixed connection block and be of any duration up to the duration of the connection block.

Figure 4 : Source Data Block Structure

Bit order within Source Data Bytes

Source data is always transmitted and received MSB first in each byte.

5. Line Encoding

The line coding scheme for High Speed D2B is *4B/5B* as described below.

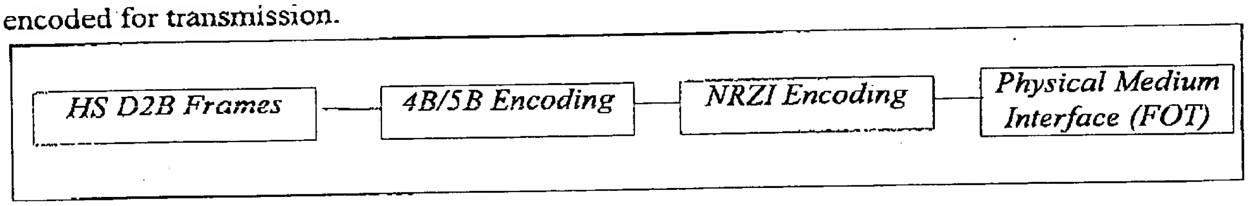
4B/5B encoding provides the following features:

- Provide an average of over 3 transitions per 5 bit symbol, to ensure easy clock recovery in the receiver
- Run length is limited to less than or equal to 5

- Free of DC frequency on average

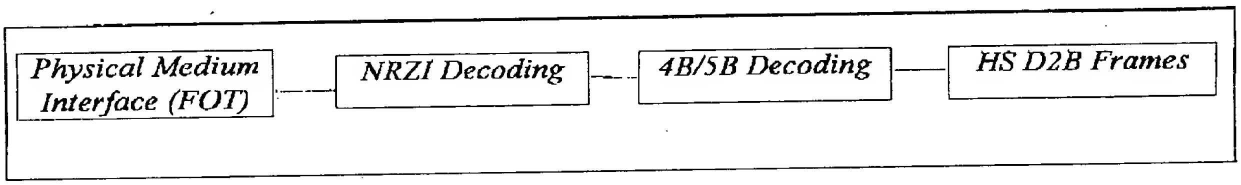
5.1.1.1 Within the Sender

The HS D2B Frame is segmented into nibbles. Each nibble (4 bits) of an HS D2B Frame to be transmitted is translated into a 5 bit symbol as shown in the table below and then NRZI encoded for transmission.



5.1.1.2 Within the Receiver

At the receiver, the received serial data is NRZI decoded and the resulting 5-bit symbols decoded to form a data nibble. The nibbles are then re-assembled into an HS D2B Frame.



5.1.1.3 4B/5B Symbol Table

Each symbol of the code is composed of 5 bits. Of the 32 possible symbols, 17 are valid in this implementation and 15 symbols are invalid. The17 valid symbols represent 16 -4 bit data nibbles (hex 0 through F) and the one Escape (X) code. The Escape code is used in the preamble of the HS D2B frame (see the following section. The table below lists the 4 - bit nibble to 5 bit symbol conversions.

Note: The binary value for 4-bit data nibble and 5 bit symbol encoded are shown as most - significant bit first (i.e. at left).

Data	Symbol	Data	Symbol	Data	Symbol	Data	Symbol
0000	11111	0001	01001	0010	01010	0011	01011
0100	00111	0101	01101	0110	01110	0111	01111
1000	10010	1001	11001	1010	11010	1011	11011
1100	10111	1101	11101	1110	11110	1111	10101
ESC(X)	00010						

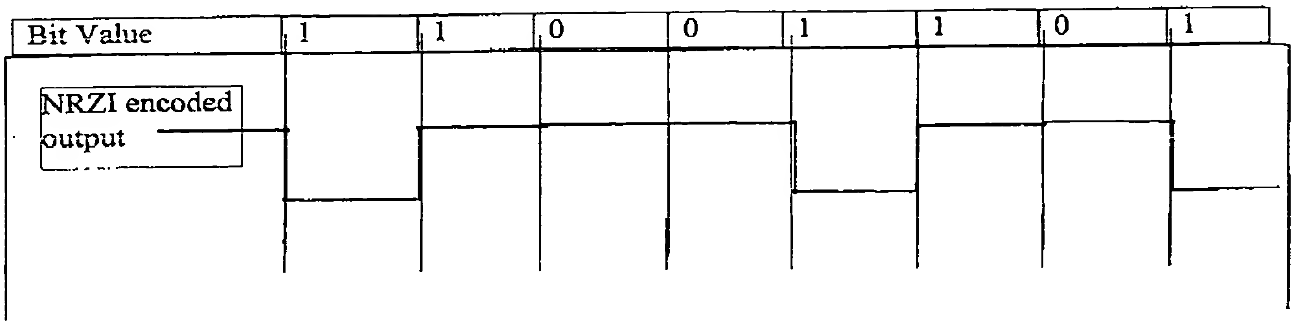
Null Data/Padding

Nibbles which do not contain null i.e invalid data (e.g. padding) will be indicated via the 5B value ('10011'B).

NRZI encoding/decoding:

Each bit of the 5 bits symbols produced by the 4B/5B encoding is further encoded such that

'1' is encoded as a transition (0 ->1 or 1->0) and '0' is encoded as a lack of a transition, as shown in the diagram below.



The serial data rate following NRZI encoding matches the serial data rate prior to the encoding, thus the use of NRZI encoding does not reduce the data transport capacity of HS D2B.

6. Source Data Transport

HS D2B can accommodate 3 different types of source data connections:

- Fixed-rate synchronous connections
- Fixed-rate asynchronous connections
- Variable-rate asynchronous connections

Fixed-Rate Connections

These are source data connections whose use of the source data capacity is fixed when the connection is set up and is guaranteed through the lifetime of the connection. This type of connection is suitable for fixed bit rate signals such as PCM audio. There are two types of fixed-rate connection: *synchronous* and *asynchronous*.

Synchronous Connections (Fixed-Rate)

These are connections which take full advantage of the raw synchronous rate provided by channels within the HS D2B source data field. There is no packet overhead associated with this type of connection and thus it is the most efficient use of system capacity subject to the limitation that the source must provide data at a rate which matches the system frame rate and the destination must be able to consume the data at exactly this rate. This type of connection could be use to transport PCM audio from a DAB receiver to an audio amplifier, for example.

Asynchronous Connections (Variable or Fixed Rate)

Source data is carried within a packet structure which allows the raw synchronous rate provided by channels within the HS D2B source data field to be adapted (padded) to data which requires delivery at some lower rate. The application may provide data for an asynchronous connection either at a constant rate or in bursts, subject to buffer capacities within the source and destination devices. HS D2B also provides a mechanism for regulating the delivery of data over an asynchronous connection according to the demands of the

destination rather than the source. For example a destination for CD-ROM data may consume data at a variable rate.

Where the bit-rate of data to be delivered over an asynchronous connection varies over a wide range e.g. by a megabit or more, a variable-rate connection should be used. This type of connection enables any spare capacity released by one variable connection to be made available to other variable connections which can make use of it. The flow control for these connections enables a destination to specify the rate (or range of rates) at which the source should deliver data to it.

6.1 Connection Set-up

Source Data Connection protocols based on control messages are used for setting-up and removing connections. These are described in [1] and [2].

Whenever source data (e.g. digital audio or video) needs to be transported over HS D2B, a source data connection must be established. This is called *connection set-up*. During the set-up, the required number of source data channels (bytes) are allocated from free capacity within the source data field of the HS D2B frame. For example, to carry a stereo audio signal from a CD player requires an allocation of 4 bytes (2 * 16 bit samples) per frame.

When all the frame's source data capacity has been allocated, attempts to build further connections will fail. When this happens, the System Master AVC must decide which existing connections (fixed or variable-rate) need to be removed to release enough capacity for any new connection. The System Master AVC is not aware of which parts of the source data field are allocated to which connections, since each device is responsible for managing the allocation in its own output link (ring segment). However, the System Master AVC can find out the type of source data delivered by a particular source, via subdevice status (the *Source Data Type* status report). The rules by which the System Master AVC selects which connections to remove first are not specified in the D2B Protocols, but form part of the Application.

For variable-rate connections, the connection set-up establishes a *reserve* allocation, although the actual allocation from source data block to source data block can be varied during the lifetime of the connection as described in the section on Variable Connection Blocks. [The *reserve* allocation of variable rate connections is used for the purpose of calculating whether there is sufficient capacity to build a new connection. This means that a new connection (variable or fixed) would not be built if it meant that a source would have to reduce the VCB width for a variable rate connection below this reserved width.]

6.2 Partitioning of the Source Data Field

The source data field is partitioned into sections carrying the different types of connections as shown in the diagram.

The first section of the source data field is allocated to variable-rate connections (if there are any): whilst the fixed-rate connections are allocated capacity starting from the end of the source data field. Any capacity remaining is grouped into the section marked 'Free'.

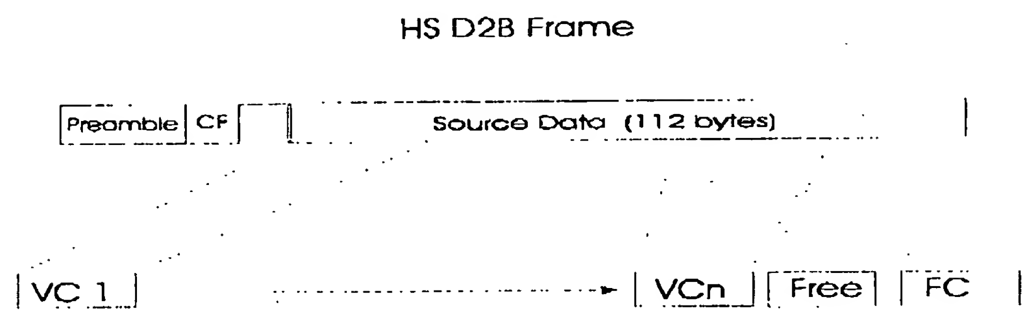


Figure 3 Partitioning of the Source Data Field

1. **VC1...VCn** are Variable-rate Connections — *V* bytes (variable)
2. **FC** represents all the Fixed-Rate Connections — *F* bytes (variable)
3. **Free** represents free capacity for VCs or the FCs — 112 - ($V+F$) bytes

7. Variable Connections

These are source data connection whose use of the source data capacity can be adjusted to meet the requirements of the application .Variable rate connections are *asynchronous* in general. The bit-rate provided by a variable rate connection depends on the number of source data bytes allocated to that connection within each frame, referred to as the width of the connection.

The format of data carried within a variable connection is a matter for the application. Padding must be inserted into the transmitted variable connection data at any time when there is no data available from the source.

The bit-rate (i.e. the width of a variable connection) cannot be varied from HS frame to HS frame, it can only be changed on source data block boundaries i.e. once per 2.25 millisecond at a frame rate of 48 kHz). Thus within a source data connection block, the width of a variable connection remains the same.

7.1 Variable Connection Block

A *Variable Connection Block* (VCB) is the collection of data for one variable-rate connection (VC) that is transported within one Source Data Block. See the section on *Source Data Block* Structure.

Variable Connection Blocks may be viewed as containers for data carried in a variable-rate connection.

1. The amount of data in a VCB is: VCB width * 108 bytes [less the header size and any restriction imposed during the Transition Period, see *Phasing In VCB Width Changes]*. Thus by varying the width of the variable-rate connection (VC) from one source data block to another, the capacity allocated to a variable-rate connection can be varied, subject to the limit of the total capacity of the frame.

2. The VCB header indicates the VC width and a reference number for that connection (the VC ID).
3. The contents of the Variable Connection Blocks are unprotected.

VCB Header

VC width	*9 bits*
VC ID	*6 bits*
Reserved	*1 bit (=0)*
Err Protection (N-K)	*16 bits*
Reserved	*1 bit (=0)*

Notes

1. The *VC width* field indicates the number of (consecutive) bytes allocated to this variable-rate connection within each frame, encoded such that 4 means 4 bytes, 5 means 5 bytes etc. The VCB width field must be set to a minimum of 4 for error protection purposes. When the VCB width field is set to 0, this indicates that the remainder of the variable connection part of the frame is free. Note that when a VCB has a width of zero in a source data block, e.g. because its destination cannot accept further data, the VC is not carried in the frame and therefore has no VCB header.
2. The *VC ID* enables a receiving device to identify the connection whose data is carried by this block.
3. BCH Encoding protection (31,16) is used to protect the preceding fields against up to 3 bit errors, allowing both detection and correction.
4. The *Reserved* field is for future extensions and should be set to zero.

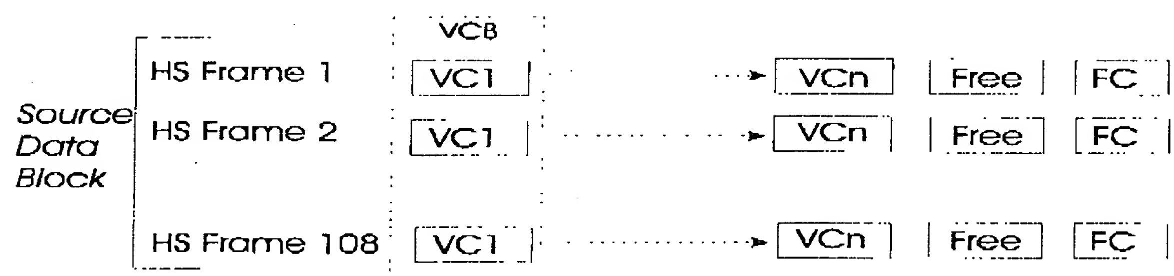


Figure 4 Structure of a Variable-Rate Connection Block

7.2 Example Application: Multiple Video Sources

The system shown on the first page consisting of a DVD server acting as a source for 4 different video signals could make use of the following source data field structure. The bit rate allocation may be varied for each connection by varying the number of bytes allocated to the Variable Connection in each source data block (the width of the variable connection). Note that since the destinations for the video signals are distributed around the system, not all variable-rate connections need to be present in all links in the system. For example, the

variable-rate connection carry the video signal to Screen 1 (video 1) needs only to be present in the link from the DVD server to Screen 1. Each of the variable-rate connections could have a starting width of e.g. 24 bytes (per frame) and then could be varied individually as required by the rate of consumption in the MPEG decoder in each screen.

Source Field Data Allocation for Multiple Video Sources

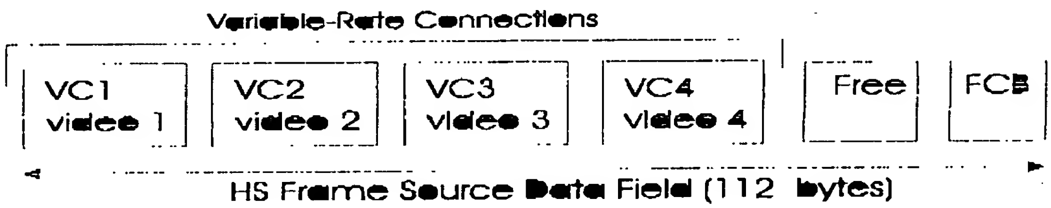


Figure 5: Example of multiplexed video connections

7.3 Variable Rate Flow Control Mechanism

Whilst a source device directly controls the rate which is allocated to its connection(s), the source device needs to receive feedback from the destination about the rate required to prevent the receiver's buffers from either becoming empty (a serious problem for real-time signals such as audio and video) or from overflowing (where the data is lost).

The mechanism enables the destination to report the minimum quantity of data that it requires to have delivered during the next block for the application to survive without interruption. The destination also reports the maximum amount of data that it can receive without its buffer overflowing. This latter information can be used to take advantage of spare capacity to spread the 'load' on the data transport capacity.

This mechanism enabled the bus capacity to be shared fairly between a number of competing variable-rate connections according their requirements and their priority.

Signalling Channel

When variable-rate connections are to be used within the system, there needs to be a *Signalling Channel* established for the purpose of transporting messages for signalling the delivery rate requirements of the destinations of these connections. This connection signalling channel takes the form of a fixed-rate synchronous connection occupying at least 1 byte of each HS frame, within the Fixed Connection section of the frame (see *6.2 Partitioning of the Source Data* Field). This channel must exist around the entire ring. This signalling channel can be built as soon as the system has started up.

7.3.1 Messages within the Connection Signalling channel

The Connection Signalling channel carries a packet, containing a message for each of the current variable-rate connections. The messages are created by their sources in the order:

1. in which those source devices are positioned in the D2B Optical ring and,
2. in order of connection ID (VC ID) (where a device is a source of multiple connections)

For example, consider a system with 3 current connections: two from the device at ring position 1 (VC IDs 1 and 2) and one from a device at ring position 2 (VC ID 4). Within the Connection Signalling packet, the following messages would be found in the order shown below:

1. Connection signalling message 1 (CSM1) from the source at ring position 1, with VC ID 1,
2. CSM2 from the same source, with VC ID 2,
3. CSM3 would be from a source at ring position 2, VC ID 4
4. The messages CSM1 to CSMN would then be transmitted again to allow devices to see the completed messages (since the messages will have been modified by their destinations during their first pass around the ring.)

[Devices are allocated a ring position, relative to the System Master, such that the System Master is at position 0, then in the direction of light propagation, the next device is at position 1 etc.]

Conn Sig Header	Conn Sig Mess 1.. N	Modified CSM 1.. N	**Padding**

Figure 9: Connection Signalling Packet Format

When a source device has initiated the building of a variable-rate connection, the source device writes the following structure into the first free message slot within the signalling channel. If the first free slot also happens to be the first slot following the start of a source data block (108 HS frames), then the source also creates the packet header as shown below.

The signalling channel then carries a packet, with the following format (starting with the first byte following the start of a block). Note that for the transmission of the modified Connection Signalling Messages, the source device in each case must store all the fields it receives from its first message and then transmit these in the next available message slot. Note that no device is permitted to overwrite any of the fields in this repeated message: thus all devices will have a chance to see this message in its final state.

7.3.1.1 Connection Signalling Packet Format

(Packet Header, type 2, (108 bytes in length))
Packet Header

Packet Type	*2 bits (=10, for type 2)*
Packet ID	*3 bits (set to 001) [1 signifies connection signalling]*
Reserved	*3 bits (=000, not used)*

Packet Data
0{ <Connection Signalling Message> }n <padding>

Connection Signalling Message

VC ID	*6 bits (or Connection ID)*
Priority of Connection	*2 bits*
Min VC width	*7 bits*

Max VC width	*7 bits*
Reserved	*1 bit*
Reserved	*1 bit*

Padding
The remaining bytes within the packet, following the connection signalling messages, are reserved. If 21 connection signalling messages are present (the maximum number), there are 2 remaining bytes.

Notes on the above packet format
1. *Packet Type* distinguishes the format of the packet from that of other types (incl. header)
2. *Packet ID* indicates the nature of the message carried by this packet, i.e. connection signalling in this case.
3. *VC ID*: matches the connection to which this message refers. A VC ID of 0 indicates that this message slot is unused.
4. *Priority of Connection Flag* indicates the priority of this signal is real-time (high priority) or non-real time. If real-time, the flag is set to '3' (high priority),, otherwise it is set to a value between '0' and '2'.
5. *Min VC width*. This field is written by the destination of the connection. It indicates the minimum width required for the specified VC within the next source data block to ensure that the destination's buffer will not be completely emptied. When a connection is not yet complete, this value remains 0, since there is no destination yet. When the connection is active, the minimum VCB width varies between 0 and the maximum width of an VCB. The first non-zero value written by the destination, following set-up of a connection, indicates the *reserve* capacity which should be allocated to this connection.
6. *Max VC width*. This field is written by the destination of the connection. It indicates the maximum width required for the specified VCB within the next Source data block to ensure that the destination's buffer will not overflow. The destination must calculate this requested maximum VC width on the expected buffer level at the end of the current source data block [in which it is making the request]. This is to prevent the buffer overflowing. The destination will be able to calculate the expected buffer size from the VC width which has been allocated by the source within the current source data block. When a connection is not yet complete, this value remains 0, since there is no destination yet. When the connection is active, this width varies between 0 and maximum width of an VC. [1 is not allowed, due to the size of the VCB Header]. [In the event that the *Max VC Width* is less than *the Min VC Width* (only possible with multiple destinations), the Max VC Width takes precedence.]
7. The *Reserved* field is for future extensions.

7.3.1.2 Limit on the Number of Variable Rate Connections

There is a limit on the number of variable rate connections which can be supported simultaneously within a system: due to the size of the connection messages and the need to repeat the messages twice.

The limit may be calculated as follows:

((width of conn. sig. channel)* (108 - Num. of frame buffers) -CS Pckt Hdr size) / (message size * num. of transmissions)

1. The width of connection signalling channel is normally 1 byte. The size of the Connection Signal Channels packet header is 1 byte. The Number of frame buffers in the system is equal to twice the number of sources in the system (including System Master), since each source contributes two frame buffers to the system. The message size is 3 bytes and there are 2 transmissions. Thus for a system containing 10 sources, the number of variable rate connections supported is:

   (108 - (10 * 2) - 1) /9 = 87/9 = 9 (when rounded down to the nearest integer)

7.3.1.3 Role of the Destination

The destination must supply the rate requirement, by writing minimum and maximum VC widths into the appropriate connection signalling message fields, to enable the source device to decide how much bit rate capacity to allocate for the next Source Data block (108 frames). The destination must also supply its ring position. [In the case where more than 1 destination is present, a destination is allowed to overwrite a previous destination in ring order, under the following conditions: (I) the *Ring position* may be overwritten if this destination is further from the source ; (II) the *Minimum requirement* may be overwritten if this destination has a higher minimum requirement; (III) the *Maximum requirement* may be overwritten if this destination has a lower maximum requirement.

Immediately after a variable-rate connection has been set-up, the destination is responsible for writing the reserve allocation requirement into the *Minimum requirement field* of the first connection signalling message for the new connection.

7.3.1.4 Rules for Sources when transmitting Connection Signalling messages

Connection signalling messages are modified by the relevant destinations during their first pass around the system,. These connection signalling messages must be transmitted again, in their modified form, by the sources which generated the original messages.

A source which is generating connection signalling messages must:

1. wait for an unused connection signalling message location (indicated by VC ID = 0) before transmitting a connection signalling message on its output (sending the message). [This rule applies both to the original transmission and also to repeat transmissions].
2. when it receives its own connection signalling message back after transmission, replace each byte of its own message with a byte containing 0 on its output. This frees the connection signalling channel for use by downstream sources.

7.3.2 Controlling a Variable Rate Connection

For determining the rate to be allocated to an variable-rate connection, the source of each variable-rate connection must take into account both the requirements of the destination(s) of that connection and also requirements of the other source data connections with which the system capacity must be shared.

There are two stages to the process:

1. a determination of which other source data connections must be taken into account
2. a determination of how much capacity (rate) should be allocated to each of these competing connections

7.3.2.1 Determination of Relevant Source Data Connections

The source must consider all the source data connections (fixed as well as variable) which affect the capacity that can be allocated to its own variable-rate connections, since the system capacity must be shared between all of these connections.

7.3.2.1.1.1 Global Search

The source looks at the ring positions of sources and destinations for each of the other source data connections in the ring. It then analyses the overlap relation between each of these connection and its own connection: either direct overlaps or indirect (where a connection which overlaps this connection is itself overlapped by another connection. See Reference 3 for an analysis of this procedure. The ring positions of sources and destinations will be provided via a *Connection* status reports *(to be defined)*. One of these will be broadcast by the System Master following successful completion of set-up for each source data connection.

7.3.2.2 Determination of Capacity for each Connection

The source data field capacity must be shared between all source data connections both fixed and variable-rate, with the fixed rate connections having a guaranteed share. If the capacity was unlimited, all destinations would be given the maximum capacity (VC width) that they have requested. However, since capacity is limited, the source must apply an algorithm to share the available variable rate capacity between the competing connections in such a way that:

1. there is the least risk of interrupting an application and
2. the available system capacity is used very efficiently, allowing more simultaneous applications to be supported.

7.3.2.2.1 Stages in the Sharing Calculation

1. Allocate the minimum requested capacity
   a) first to all the high priority connections in order of VC
   b) secondly to the lower priority Connections
2. Allocate the remaining capacity: (There are 3 alternatives here)
   a) weighted according to the remaining requested capacity for each connection (max-min)
   b) round robin allocation of to each connection in turn
   c) allocation of the full requested capacity to each connection in turn

7.3.2.2.2 Stage 1: Allocation of Minimum Requested Capacity

1. The source device calculates the total *available width* (capacity) by forming the sum of all current VC widths and the free width.
2. The source device should 'allocate' the minimum requested width to each of the relevant connections,
   a) first, to high priority connections in the order in which they are represented in the signalling channel
   b) to low priority connections, in signalling channel order

This stage ends either when there is no remaining available capacity or when all relevant connections have been allocated their minimum requested capacity.

7.3.2.2.3 Stage 2: Allocation of Minimum Requested Capacity

If any capacity remains following Stage 1, it will be allocated to the relevant connections according to the following method.

Allocation to each connection in turn

In this method the full requested allocation is given to each high priority connection in connection signal channel order until all the capacity is used or until all high priority connections have their full requested allocation (Max VC Width, including the allocation from Stage1).

If any capacity remains, then it is allocated giving the full requested allocation to each low priority connection in connection signal channel order until all the capacity is used.

7.3.2.2.4 Implementing the VC width which has been calculated

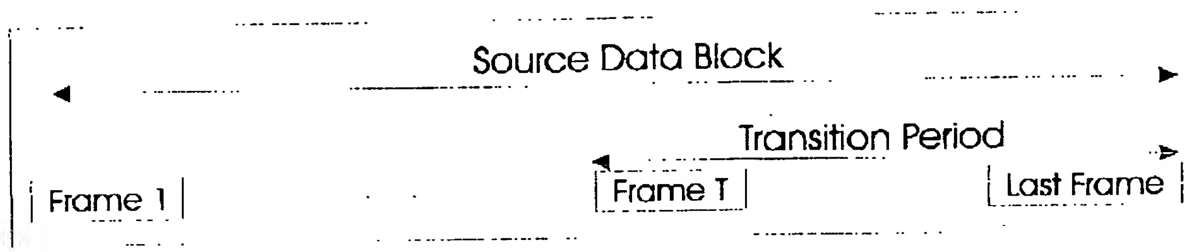
1. Each source may only set the width of its own VC, according to the allocation calculation described above. Further if the new width is less than the width in the current block, then the width reduction must be phased in. See the section *Phasing in VC Width Changes*.
2. Each source must remove the VCs for any destination which precedes it in ring order and must shift the higher VCs down to fill the gap left by the deleted VC(s).

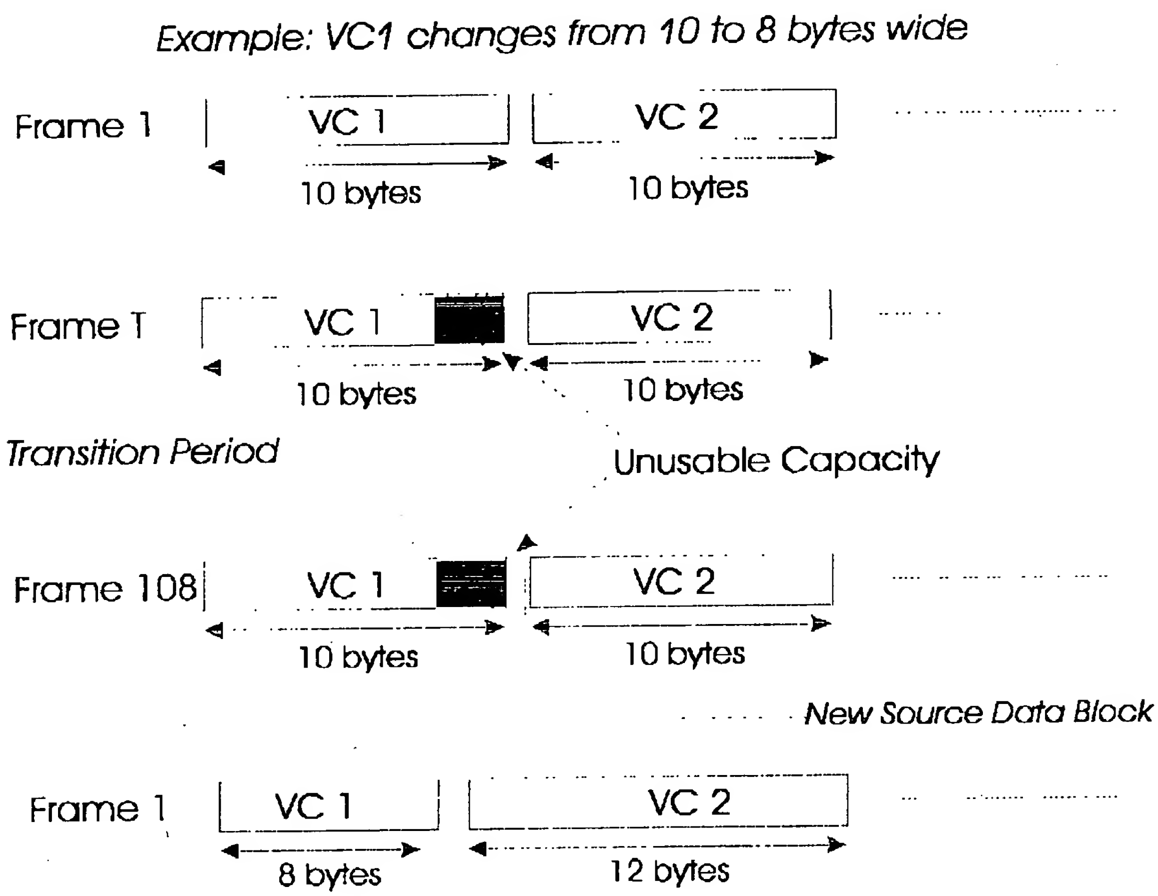
7.4 Phasing in VC Width Changes

Because of the presence of source data buffers distributed around the ring (whose number depends on the ring configuration), the changes in VC width cannot in general be completed within a single frame. Each source must start making adjustments to meet the calculated VC size for the next Source Data Block at the start of an interval called the Transition Period. The Transition Period is the period during which the master is transmitting frames in the old source data block whose contents will be copied by the system master into the first frames of the new source data block.

Frames transmitted by the system master during the transition period are marked via the *Tr* bit in the HS D2B frame. When loading frames which are in the Transition period, sources which are due to reduce their VC size in the next source data block must use only the width of VC which will be allowed in the next block (i.e. bytes are wasted at the end of the VCB within each of the frames in the Transition Period. Sources which are due to increase their VC size may only do so in the first frame of the new source data block. Note that

1. All connection signalling messages must complete their final pass around the ring before the start of the Transition period. This means that the number of simultanvariable connections
2. During a period equal to the transition period following the start of a new source data block, VCs whose size has increased contain only the same amount of data as the corresponding (smaller) VCs in the previous source data block. This only applies to the section of the ring between the Master and the source for that VC.
3. The number of frames in the Transition Period is equal to the number of sources * 2, where the system master is always counted as a source.





7.5 Example of Variable Rate Connections

In the diagram below, connections 1 and 2 and 3 overlap over a number of segments in the ring. Thus the capacity allocated to connection 1 will limit the allocations which can be made for Connections 2 and 3. To ensure fairness of sharing bus capacity (and thus maximise the number of simultaneous applications supported within the system) the source of connection 1

should also take into account the buffer occupancies and priorities of connections 2 and 3, when deciding what bit-rate it should use for its own output.

1. Connection 1 (Source 1 to Destination 1) is for a compressed video signal (a real-time signal, therefore high priority)
2. Connection 2 (Source 2 to Destination 2) is for map data from a CD-ROM (non-real time, therefore low priority)
3. Connection 3 (Source 3 to Destination 3) is compressed video (high priority)

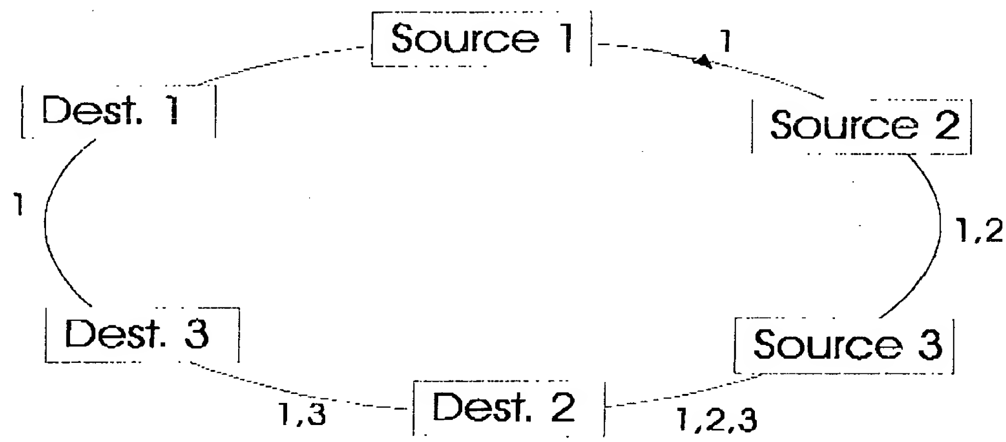


Figure 10: Overlapping Connection Example

Initialisation

Each connection is set-up with a reserve VC width determined by the expected rate or by the size of the free block, from which bytes are allocated for the new VC.

Suppose, for this example, that the total available width for VCs is 80 bytes (including the Free block), since the remaining bytes of the source data field have been allocated to the fixed-rate connections.

Actions of source 1

Suppose that at the start of Source Data Block *n*,

1. Destination 1 decides that it needs a width which is a minimum of 5 and a maximum of 10 bytes. [This will lead to a delivery of between 510 and 1020 bytes during the Source data block, assuming that at least the minimum requested capacity is available.]
2. Destination 2 decides that it needs a width which is a minimum of 10 and a maximum of 50 bytes (VCB width).
3. Destination 3 decides that it needs a width which is a minimum of 20 and a maximum of 40 bytes (VCB width).

The calculations given in stages 1 and 2 (alternative 1) apply to the calculation in this example.

Source 1 is aware of the requirements of all these destinations and tries first to allocate the maximum requested widths (total 10+50+40=100), but finds that this exceeds the available

width (80). Then source 1 allocates the minimum requested capacity to each connection (5 + 10 + 20 = 35) and then shares the remaining capacity (80-35=45) between the high priority connections (from source 1 and source 3), leading to an additional width of

- 5 for Source 1
- 40 for Source 2
- 0 for Source 3
- There is no remaining width

Finally source 1 calculates the VCB width for connection 1: 5 + 5 = 10 bytes. This change will be phased-in as described above.

Actions of source 2
Source 2 will have received the same information from destinations 1,2,3. It will perform the same calculation as source 1, leading to a VCB width of 10+40 = 50 bytes which it will set for connection 2. This change will be phased-in in as described above.

Actions of source 3
Source 3 will have received the same information from destinations 1,2,3. It will perform the same calculation as sources 1 and 2, leading to a VCB width of 20+0 = 20 bytes which it will set for connection 3. This change will be phased-in in as described above.

8. Free Capacity (Free)

The free capacity is treated as a Variable Connection (VC) with ID = 0.

9. Fixed Connections (FC)

This last section of the source data field can be used to carry both *synchronous* signals e.g. 16 bit PCM audio at 48 kHz or *asynchronous* signals whose bit-rate is fixed. Changes to the contents and size of this block can only be made by setting up a new connection or removing an old connection. These operations are defined in the *Source Data Connection Protocols* [1]and in . *Source Data Connection Protocols: Extensions v0.1 [2]*

9.1 Fixed-Rate Asynchronous Connections

A fixed-rate asynchronous connection carries unformatted source data, modified only by the insertion of padding to match the bit-rate of the connection to the requirements of the application.

Padding
Padding is inserted into an asynchronous connection whenever there is no data available from the source. The insertion of padding reduces the effective bit-rate of the connection to match the output from the source.

Flow Control
In some applications, the source is able to deliver data at a range of bit-rate and it is the destination which must regulate the bit-rate in order to avoid overflow and thus loss of data in the receiver. The flow control mechanism enables the receiver to feedback a *stop/continue*

indicator to the source. The *stop* indicator forces the source to stop transmitting data and to fill the connection with padding until a *continue* indicator is received

9.1.1 Fixed Rate Flow Control Mechanism

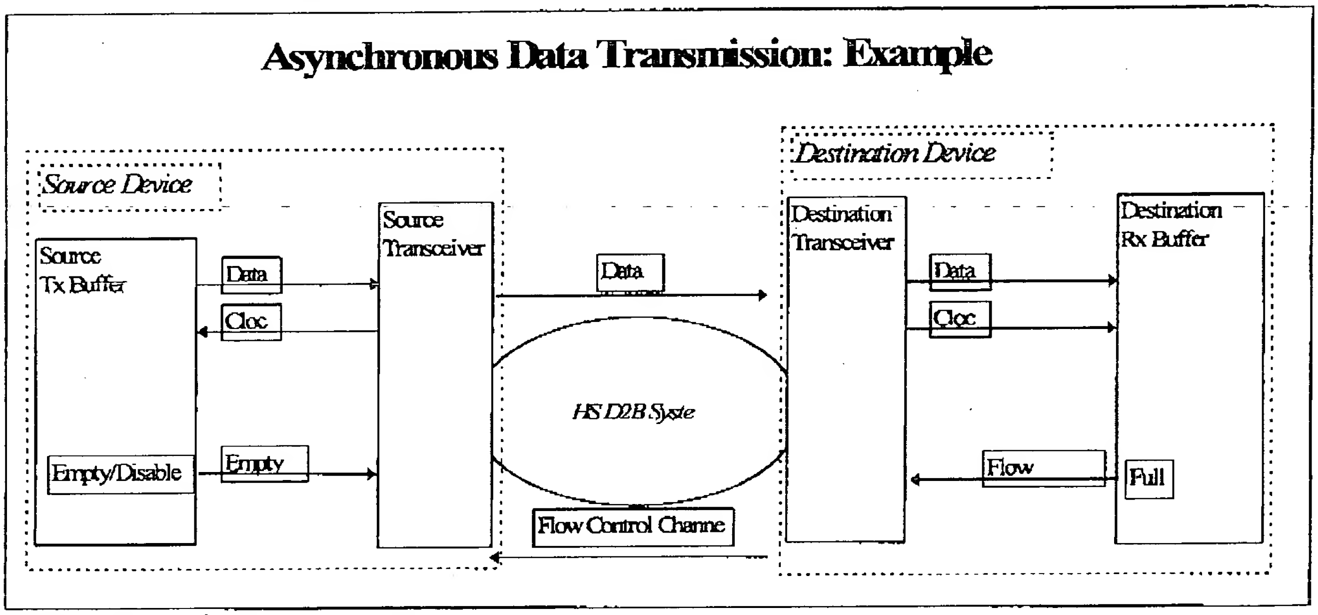
When a fixed-rate asynchronous connection is built, the system allocates a single bit within *a flow control connection* byte to carry the a *stop/continue* indicator. The *flow control connection* is built around the ring from the System Master to the destination. [The System Master may build this *flow control connection* any time after the system initialisation is complete following start-up.

The bits are allocated in connection ID order, when fixed-rate connections are set up. The bits are released when fixed-rate connections are removed, thus becoming available for use with new connections.

The following range of connection IDs apply to Fixed Asynchronous Connections:

'20'H: Flow Control Connection

'21' .. '30'H Fixed Asynchronous Connections



Explanation of Above Diagram

The above diagram shows a source device sending data to a destination device over a fixed asynchronous connection (FC) on HS D2B.

The *'Empty'* indicator from the source's (Tx) buffer together with the Flow Control Bit determine whether or not padding needs to be inserted into the transmitted FC datastream.

The *'Full'* indicator from the destination's (Rx) buffer is used to determine the state of the flow control bit. Note that the 'full' level has to be set to take into account the latency described in the section below.

Multiple Destinations

In the case where there are multiple destinations, the flow control outputs are Ored together in the same flow control bit. Thus the device whose buffer fills first will set the flow control bit to stop. If the application wishes to pause delivery to one particular destination, then the flow

control output from that destination should be kept at '0' (continue) so that data can continue to be delivered to the other destinations for that connection.

When the Source Buffer is not empty & the Destination Buffer is not full
[In the Source] Data is transferred from the Tx Buffer into the bytes allocated to the (fixed asynch. connection) FC within the source data field of the HS D2B frame.

[In the Destination] Data is copied from the bytes allocated to the FC within the source data field of the HS D2B frame into the Rx Buffer

When the Source Buffer is empty & the Destination Buffer is not full
[In the Source] No Data is transferred from the Tx Buffer, so padding is inserted into the bytes allocated to the FC within the source data field of the HS D2B frame.

[In the Destination] Padding is recognised by the receiver and thus no data is into the Rx Buffer

When the Source Buffer is not empty & the Destination Buffer is nearly full
[In the Source] Data is transferred from the Tx Buffer into the bytes allocated to the FC within the source data field of the HS D2B frame.

[In the Destination] Data is copied from the bytes allocated to the FC within the source data field of the HS D2B frame into the Rx Buffer. When the buffer reaches full (less an amount due to the latency), the destination sets the Flow Control bit to '1' (meaning stop).

When the Source detects that the Flow Control is set to Stop
[In the Source] No Data is transferred from the Tx Buffer, so padding is inserted into the bytes allocated to the FC within the source data field of the HS D2B frame.

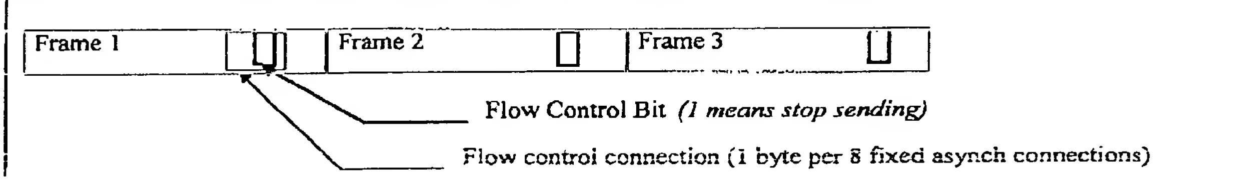
[In the Destination] Padding is recognised by the receiver and thus no data is into the Rx Buffer. When the buffer is no longer full, the receiver sets the corresponding Flow Control bit to '0' (meaning continue).

When the Destination Buffer is no longer full
[In the Destination] The destination sets the Flow Control bit to '0' (meaning stop).

When the Source detects that the Flow Control is set to Continue
[In the Source] Data is transferred from the Tx Buffer into the bytes allocated to the FC within the source data field of the HS D2B frame.

[In the Destination] Data is copied from the bytes allocated to the FC within the source data field of the HS D2B frame into the Rx Buffer

Flow Control Connection: Signalling from Destination to Source



9.1.1.1 Latency of Flow Control

Allowance must be made for delay in the effect of the flow control bit, due to the number of source data fields of HS D2B frames which are held in buffers around the ring. This means that the *flow control bit* ('1' means stop, '0' means start/continue) needs to be asserted before the receiver buffer is full, taking into account the amount of data which will be received before the flow control takes effect. This depends on the number of bytes used per frame (for this connection) and on the number of devices with open source data bypasses in the system.

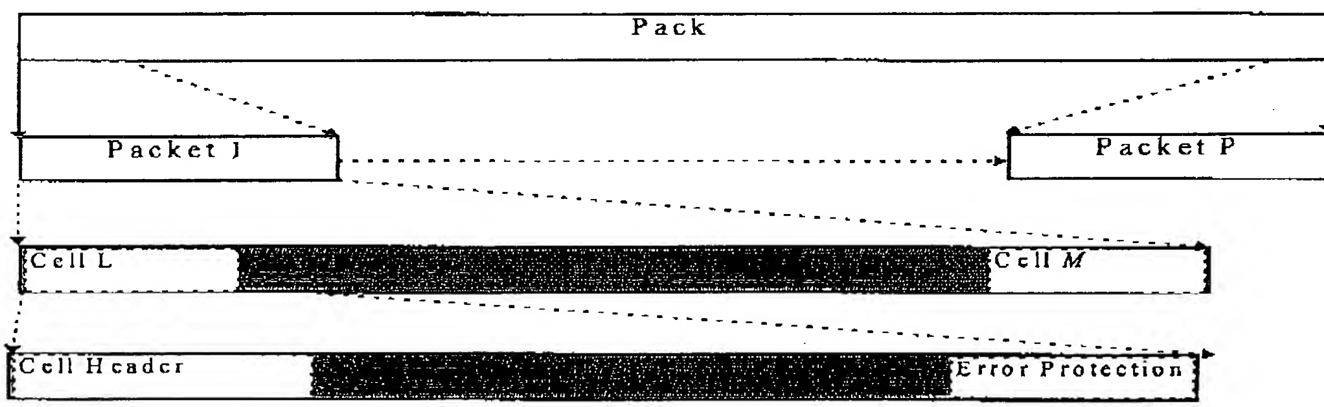
The total latency (in bytes): *L = (number of sources * 2) * number of bytes in FC per frame,*

where FC stands for *Fixed Asynch. Connection* and the System Master is always counted as a source.

This latency can be measured by the System Master when the system starts up, by counting the number of frames which elapse between transmission and reception of the frame containing the start of a source data block (indicated by the SDB bit set to 1 in the HS D2B frame header). The System Master then marks this number of frames at the end of the source data block with the *Transition Period* flag *Tr* set to 1.

10. Pack/Packet/Cell Hierarchy

The contents of a source data connection, either fixed or variable, are determined by the application. The following is a proposal for one possible form of organisation.



Key: *L* .... Indicates that the first cell of a packet is not necessarily the first cell of an of a connection block (FCB or VCB)

M ..... A packet must contain at least one cell and may contain a number of cells (given by M-L+1

P ..... The number of packets in a pack is defined by the application within the limits imposed by the *Remaining packets* field in the cell header: up to 256 packets/pack are supported

Figure 6: Pack,Packet and Cell Hierarchy

A packet of source data may occupy an integral number of cells. The packets themselves may also be part of a pack as shown in the diagram above. The application may define the number of packets in a pack as well as the number of cells in a packet (1 or more, subject to the limit

imposed by the *Remaining Packets* field in the cell header), using the fields provided in the packet-slot header.

10.1 Cell Structure

The cell provides framing to allow a device receiving the data to identify the data and recover it correctly. See the diagram above for an illustration of the structure.

Cell Header

Start of Packet flag	*1 bit*
Start of Pack	*1 bit*
Packet Type	*3 bits (=01, for packet type 1)*
Remaining Packets	*8 bits*
Number of bytes in Cell	*10 bits*
Error Protection (N-K)	*8 bits*

Notes

1. The *Start of Packet* flag indicates whether the first data byte of this cell is also the first byte of a packet (flag set to 1) or whether it is a continuation of a packet.
2. The *Packet Type* identifies the remaining format of the cell. Cell type 0 indicates an unoccupied cell, i.e. no packet data.
3. *Remaining Packets* indicates the number of packets remaining within the current pack (group of packets)
4. *Number of Bytes in Cell* indicates the number of bytes in this cell which contain valid data
5. The *Error Protection* field use is currently undefined.

10.1.1.1 Cell Data

Data 102 bytes

The data contained in the cell is unprotected against errors

10.1.1.2 Alignment of a cell within a Packet

The start of the packet is indicated by the *Start of Packet* bit (set to '1') in the cell header. When this bit is set, the first byte of data following the cell header is also the first byte of the packet data (as opposed to being a continuation of a previous packet). When this bit is not set, it indicates that the contents of this cell are a continuation of a packet sent in the previous cell.

Amount of a Fixed Connection Block (FCB) occupied by a Cell

The number of HS frames required for transmission of a cell is a function of the size of the cell (108 bytes) and the width of its containing FC in each HS Frame. If the FC is *n* bytes wide then the cell will encompass $(108)/n$ HS frames. Note that this calculation applies only to Fixed Connection blocks, since VCB have a reduced capacity during the transition period.

11. References

1. *D2B Optical Specifications: Common Protocols v2.2*, April 1997, Communication & Control Electronics Ltd..

2. *Source Data Connection Protocols: Extensions v0.1*, which defines application level protocols: still in preparation.

3. Search Algorithm for High Speed D2B Byte Allocation, Brian McGovern, 1st August 1997.

12. Change History

Changes since Version 0.4.7

1. Frame format changed
   a) removed parity bit at the end of the frame
   b) removed transparent channels (now redundant)
   c) reduced reserved bits from 6 to 2
   d) increase source data field by 1 byte to 112 bytes
   e) moved CF field to be adjacent to preamble
   f) corrected frame period to 20.83 microseconds
2. 4B/5B Table has been modified: 5B values for '0', and 'F' have been exchanged to increase the number of clock transitions when the frame data is zero.
3. A 5B value from outside the table has been chosen for presenting null data.
4. Control Frame Arbitration field is expanded to 4 bits
5. Variable Connections have their own header
6. Packet Slot is now renamed to Cell and is decoupled from FCB or VCB boundaries
7. Pack, Packet and Cell Structure passed to application level
8. Alternatives for Variable Rate Flow Control have now been eliminated.
9. Error Protection has been added to the Connection Signalling Messages

Changes since Version 0.4.7a

1. Frame structure changed to unify the source data field, and the size of the source data field is now increased to 111 bytes
2. Description of fixed asynchronous connections has been added together with a simple flow control mechanism.
3. The 108 byte unit carried within VCBs is now called a cell instead of a packet to simplify understanding of the pack/packet hierarchy.
4. Small adjustments to the sharing calculation (weighted method)h

Changes since Version 0.4.7

1. Extension of description of alternative sharing method
2. Further description of the 'Phasing-In' Period.
3. Access rules for sources which use the Connection Signalling Channel
4. Added mechanism for flagging master buffer occupancy

Changes since Version 0.4.6

1. Delay to Transparent Channels is now matched with the delay to data in the source data field.
2. An outline description of a possible alternative capacity sharing algorithm is given, based on each source calculating for its own point in the ring.

Changes since Version 0.4.5

1. Addition of a *Start of HS D2B Block* bit in the last byte of the first part of the HS D2B frame
2. ACB has been renamed VCB (variable-rate connection block), and SCB has been renamed to FCB (fixed-rate connection block).
3. A new Source Data Block has been defined, consisting of 108 frames, not aligned with the normal (48-frame) HS D2B Block which is used for control frame message transport.
4. The VCB header has been merged with the Packet Header to reduce overheads
5. A one-byte wide VCB is now supported
6. The packet size has been increased to 108 bytes to reduce overheads
7. The connection signalling message format has changed to include ring positions of source and the furthest destination to allow each source to determine which connections overlap its own.
8. The allocation sharing algorithm has been refined to give a less wasteful sharing of surplus capacity once the minimum requirements have been met. Each source must also take into account the sources which overlap their connection but also the sources whose sources are overlapped by these overlapping connection and so on until all relevant sources are included in the calculation.
9. Sources are now responsible for removing ACBs of connections whose furthest destination precedes this source in ring position.
10. Support for S/PDIF's 'VUC and S' bits is now provided via the normal source data field, i.e. if a connection needs to carry these then it must allocate an extra byte for this purpose. The byte will then carry : left VUC (3 bits); right 3 bits);

Changes since Version 0.4.4

1. Alteration of frame structure to accommodate 8-bit frame preamble needed for 4B5B Coding. Subframe preambles are no longer used.
2. The S/PDIF bits (VUC and SB) must now be routed in a normal source data byte instead of having reserved bit fields at the end of the frame.

Changes since Version 0.4.3

1. Source Data Bytes per sub-frame increased to 55.

Changes since Version 0.4.2

Line Coding section added.

CLAIMS

1. A local communication system comprising a ring network conveying source data in both variable rate and fixed rate channels, by means of a regular frame structure, each frame providing a fixed number of source data fields, wherein each fields can be reserved dynamically to form part of a fixed-rate channel using the same fields in each frame, and at other times can be allocated to form part of a variable rate channel for irregular data packets.

2. A system according to claim 1, wherein blocks for fixed rate data are allocated starting from one end of the frame, while fields for variable rate data are allocated starting at the other end of the frame.

3. A system according to claim 1 or 2, wherein successive frames are grouped into blocks, and each variable rate channel occupies the same fields through all frames of a block, fields being reallocated to provide variation of channel width only at the start of each block.

4. A system according to claim 1, 2 or 3, wherein a block header is transmitted to reserve a variable rate channel of a specified width for a plurality of

successive frames.

5. A system according to claim 4, wherein said block header occupies one or more fields of the channel for at least the first frame of the block.

6. A system according to claim 4 or 5, wherein at the start of a block, each channel's block header occupies one or more fields which can be located in the frame with reference to the widths of other channels.

7. A system according to any preceding claim, wherein each variable rate channel comprises a selection of fields fixed over a predetermined sized block of frames, the width of all such channels being specified in the source data fields of the first frame or frames of each block.

8. A local communication system comprising a ring network conveying source data in both variable rate and fixed rate channels, by means of a regular frame structure in which certain portions of each frame are reserved for said fixed rate channels, whether or not said fixed rate channels are in use, and certain other portions of each frame are available for said variable rate channels, and a control mechanism is provided for allocating said variable rate portion dynamically between

different channels.

9. A system according to claim 1, 2 or 8, wherein the frame rate is synchronised with one or more digital audio data sources, for which source data is carried in the fixed rate portions of each frame.

10. A system according to claim 1, 2, 8 or 9, wherein each frame conveys control bits forming part of a control message frame transmitted over plural frames.

11. A local communication system comprising a synchronous ring network conveying source data in a fixed rate channel over one segment of the ring and while said fixed rate channel is multiplexed with variable rate channels over another segment of the ring.

12. A system according to claim 11, wherein said multiplexed fixed rate channels and variable rate channels comprise different respective portions within a regular frame structure on said other segment of the ring.

13. A fibre optic local communication system, for example according to any of claims 1 to 12, suitable for in-vehicle entertainment, communication and/or navigation purposes, having an overall source data capacity greater

than 10 Mbps, the fibre optic channel conveying 4B5B or 8B10B encoded data.

14. A system according to any preceding claim, wherein variable data source data channels are mapped on to the network in asynchronous transfer mode packets.

15. A fibre optic local communication system, for example according to any of claims 1 to 12, suitable for in-vehicle entertainment, communication and/or navigation purposes, having an overall source data capacity greater than 10 Mbps, the source data comprising variable data rate audio and video data, carried by asynchronous transfer mode (ATM) packets.

16. A system according to claim 15, wherein the headers and data fields of ATM packets do not necessarily consist of 5 bytes and 48 bytes respectively.

17. A local communication system substantially as described herein.